DISCOVERY

THE PROGRESS OF SCIENCE

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A process control laboratory at the Windscale Plutonium Factory, which was shown to the British Press for the first time last month.

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DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

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THE PROGRESS OF SCIENCE

THE FUTURE OF BRITISH SOCIOLOGY

The men who ploughed the fields on which the social scientists are now sowing their seeds were philosophers and theologians. From Plato to Marx they were practically all men who had an axe to grind, men who aimed at achieving some fine moral objective such as a definition of 'The Good State' or 'The Ideal State'.

They did not approach their studies as scientists, but much of the same ground that they covered is today covered by social scientists. To some extent, therefore, the modern social scientists are their heirs, having inherited their territory. But in our present age the success of the scientific attitude in the natural sciences has induced the successors of the moral philosophers and theologians to model their methods and research techniques on the fruitful examples which have brought so much prestige to the natural scientists. Disillusionment with the 'axe-grinding' type of social approach was another factor that prompted the search for more scientific ways of tackling this field of study. Out of these efforts has come the modern conception of the social science we call sociology. It is sometimes argued by natural scientists that this is not a science at all because its boundaries have not been closely defined; but if that is a fair objection, then it is an objection which a sociologist would be entitled to apply to biology, the frontiers of which are just as fluid.

Many who reject the idea that there is one key social science called sociology find no difficulty in accepting the plural term 'social sciences', for they have no doubt about the existence of the separate disciplines such as economics, psychology, anthropology and so on. The separation of these subjects from each other is advantageous in certain respects, but it also leads to certain difficulties. Thus it is commonly found that when a social problem is analysed with the tools belonging to only one of these isolated, specialised disciplines the result is a quite unsatisfactory diagnosis. The diagnosis proves to be inadequate, and the reason for that is simply that the diagnostic set of tools of the one particular specialism is inadequate when used on its own and not in conjunction with tools belonging to the other specialisms.

The ramifications of social problems are such as to require a simultaneous and carefully balanced study by *all* the social sciences. Ever since the days of Auguste Comte, there has been a school of thought favouring the development of a science with techniques of synthesis and of 'relational thinking' in this field. Something more than the analytical approach is undoubtedly required, as will be readily appreciated if one considers a subject such as delinquency, where it is manifest that no single psychological, economic, medical or ethical explanation is sufficient to enlighten us about the causes of delinquency. There is clearly a legitimate place for an integrating discipline; this master key to the social sciences could materialise if sociology could be raised to the full stature it is capable of attaining.

We cited delinquency as a subject requiring sociological study, and not just analysis by specialists in the different social sciences. This is but one example out of the many which could be quoted to illustrate the need to establish an integrating discipline equal to the task of linking together the different specialised approaches.

The master science of sociology is slow maturing. One reason is that the sociologists are still feeling their way. They feel safer when they are analysing problems rather than synthesising a solution of those problems. They are chary of accepting, or even of seeking, a general theoretical structure for their science. Their cautiousness is partially explained by their natural desire to avoid the faults of the dogmatic sociological systems of the past.

The situation is somewhat comparable to that which exists in the field of town planning. The town planner has his standards of perfection, but he knows that these are virtually impossible of practical achievement. He cannot hope to reach his ideals of perfection for the very compelling reason that buildings must be constructed to keep pace with the needs of a developing community. *Ad hoc* decisions about building projects have to be taken and put into operation rapidly, even where it is certain that a better set of decisions could be taken if the planners were permitted the luxury of deferring their decisions until they had collected and assessed all the relevant facts. The town

planner aims at the highest degree of well-ordered development of an area, but 'the highest degree' is quite unlikely to come up to his ideals of perfection. Nevertheless he is entitled to be well satisfied when he looks at his practical achievements and sees that they have a quality which places them in a class altogether different from the jerry-built conurbations of yesteryear. Behind modern town planning lies a considerable body of theoretical work, which serves to guide and inspire the practical efforts of the experts in this field. In many respects, sociology finds itself in an analogous position. Applied sociology is an eminently practical subject like town planning, and equally the problems which it sets out to solve call for rapid solution. This applied sociology needs to be based on a sound basis of theory, a clear understanding of the fundamental principles that are involved; the theoreticians therefore have an immensely important role to play. The distinctive task of sociology is to meet the need for synthesis, the need to achieve integration between the separate social sciences. That kind of synthesis presupposes a generous allowance of research time and a liberal staffing of university departments of sociology.

We should like to see more money being allocated to this subject in Britain. We are prompted to say this by the publication of the Unesco publication entitled *The Teaching of the Social Sciences in the United Kingdom*, from which one is bound to conclude that sociology is not well supported in British universities. The document contains reports by British social scientists on the state of their respective specialisms and of the teaching facilities which exist for those specialisms in this country. It is a very useful booklet because it provides an authentic picture of the personnel, curricula, range of tuition and research in the social science branches of our universities.

The term 'social sciences' figures in the title of this collection of reports, and sociology as a distinct subject is allotted no more than a part of one of the five constituent chapters. (The relevant chapter is headed "The Teaching of Sociology, Social Anthropology and Social Psychology".) The other chapters account for economics, political science, international relations and law. The report on law forms the longest chapter in the booklet; it is hard to see any justification for giving it so much space, but perhaps someone thought it deserved such special attention because it was the first type of social study to gain a place in the universities!

There is a curious discrepancy in Britain between the status which is accorded to sociology in the universities, and the widespread appreciation of the worth of applied sociology. That appreciation is regularly in evidence in the many advertisements for posts in government service and in industry and commerce which stipulate that applicants must have had training in sociology. In contrast one meets in academic circles some inflexibility towards the claims of sociology to be recognised at its true value. This applies particularly to the older universities. One gets some idea of the academic attitude towards sociology by considering the status which is given to the subject in teachers' training courses. There is only one British chair for the Sociology of Education; that chair was created by London University, and it has in fact been empty ever since the retirement of Prof. Lester Smith.

Sociology receives much more encouragement in the U.S.A. According to the *American Journal of Sociology* (May 1945), there existed in the period 1940–4 no less than 441 universities and colleges offering tuition in sociology. They provided altogether 5260 courses in the subject, not counting courses in anthropology and social work. It is obvious that our provisions in this field are far below that which we would reasonably expect on the basis of comparison between size of population and the numbers of teaching institutions and students at the universities. Sociology is conspicuously represented in the departments of education in American universities, and there can be little doubt that a more energetic sociological programme in those departments of British universities would bring substantial benefits to sociology as a whole.

On the research side, too, we would hope to see British sociologists given encouragement comparable to that which their American counterparts enjoy. An expansion of sociological research here is a crying need. We can see one particular sociological research project for which a generous grant is overdue. The working of the social services, the assessment of their value to the community, the qualities of their personnel and the planning of their future development must no longer be left to intuitive appraisal, to small sectional investigations or to political exploitation. Here is a potential area of sociological research which should attract substantial funds, for the direct usefulness of the results of such an investigation would be tremendous.

In connexion with education—in the training of teachers specifically—and with the social services, Britain could profitably employ more sociologists. If that were done, the expansion of the sociological departments in our universities would be bound to follow.

In the Unesco report there is a detailed account of the design of the new B.A./B.SC. (London) degrees in sociology. There are three options: (*a*) a course in pure sociology; (*b*) a course in sociology with special reference to social administration and the work of the British social services; and (*c*) a course in sociology and social anthropology. The second of those options is a welcome development, but it is regrettable that there is no option for the Sociology of Education.

The higher synthesis with which sociology must more and more concern itself if the subject is to advance is a matter for post-graduate study and research. The opportunities that exist for this in British universities are far below what is needed. This fact was brought home to us by a rather curious passage in the Unesco booklet. Here it is stated quite categorically that an aptitude for higher level synthesis is rarely present in the young sociology graduates, but afterwards one comes to this contradictory statement referring to post-graduate work: "It is from amongst students placed in the first class at the final honours examination that the academic lecturers and teachers at the universities are chiefly selected, and it is not unknown for them to start on the lowest rung of the academic ladder at the age of 22 or 23. It may be observed that, so far as candidates from British universities are concerned, the possession of a first class in the final honours examination is normally regarded as a stronger

qualification for an academic teaching post than the possession of a higher degree, such as a Ph.D." Admittedly this passage occurs in the section on economics, but the document leaves one to suppose that the same thing applies in the teaching of sociology. If very young graduates dominate the teaching of sociology, then there is very little chance that the sociology taught in our universities can be of the kind that needs to be taught. An effective teacher of this subject must have had the time to speculate about the subject and to have done some really deep thinking. The coveted synthesis which should characterise sociology presupposes field experience and a maturity of thought practically impossible of attainment by any graduate of 22 or 23 years.

Advanced work in the social sciences does not appear to be highly prized, if one may judge by the following statement which appears in the Unesco report: "*Only a very small minority of Economics teachers at British universities (including professors) hold the Ph.D. degree.*"

In Britain possession of a Ph.D. in the natural sciences has come to be regarded as little more than the badge of the apprentice research worker. The research which wins a Ph.D. is rarely regarded as having any great significance *per se*; rather it is regarded as an exercise that establishes whether an individual possesses the aptitude for research. Today in chemistry, physics and biology the Ph.D. is not looked upon as a rare bird, and indeed we have by now a great many people with Ph.Ds in Britain. The scarcity of Ph.Ds in the social sciences would seem to suggest that research in these sciences is not very flourishing, and apparently only a few of the people who study sociology to degree level go on to do research in this subject. It is inconceivable that this state of affairs could arise because British sociologists do not want to advance knowledge of their subject. One is forced to conclude that the cause is that the support given to sociological research is quite insufficient.

'HIBERNATION' IN OPERATING THEATRES

Many patients to whom a major operation could bring a new lease of life often cannot be given the surgical treatment which would benefit them because they are what is commonly known in medical circles as 'poor operational risks'. For instance, the surgeon may conclude that a particular patient could not stand the anaesthetic, or that the patient's general physical condition is not good enough to cope with the shock of the operation. At that point the surgeon would be bound to decide against an operation. This kind of situation is an everlasting challenge to the surgeon's skill. The aim is always to minimise the proportion of inoperable cases, an aim which inspires the search for better and safer techniques of both surgery and anaesthesia.

One striking advance followed the introduction some years ago of the muscle-relaxing drugs, which have made a great difference to abdominal and chest operations in which a considerable degree of muscular relaxation is desirable. Formerly this could only be obtained by very deep anaesthesia. That is at a level far beyond that required merely to render the patient unconscious and oblivious to pain. Extracts of curare, the S. American arrow poison, and the new synthetic muscle-relaxing drugs such as Flaxedil and Laudexium, provide relaxation of muscle, and the depth of anaesthesia, therefore, need only be sufficient to render the patient unconscious and unaware of pain.

Now another development and perhaps one of the most interesting has come along. It is termed *artificial hibernation*. In spite of the benefits provided by muscle relaxants, there are still many patients who cannot undergo an operation because of the risk from surgical shock.

The chief symptom of shock is a severe drop in blood pressure which can lead to a serious shortage of oxygen in all parts of the body. Anaesthetists combat the problem of shock in several ways: drugs such as adrenalin and ephedrine, which constrict the blood vessels and stimulate the heart, are injected to raise the blood pressure; the blood volume is increased by transfusion; the patient can be given almost pure oxygen to breathe. In a fairly robust patient these measures will nearly always work satisfactorily, but a patient with, for example, a weak heart might not be able to withstand such treatment and then the surgeon would have to decide against an operation.

The new technique of artificial hibernation, so named because it depends on the production of a state resembling the natural hibernation condition that can be observed in many mammals, tackles the problem from an entirely different angle. Instead of attempting to increase the oxygen supply to the tissues, the reverse is the aim, and the oxygen requirements of the body are reduced

For many years it has been recognised that the metabolic rate of hibernating animals is far below their normal rate. One index of this is the great reduction in the rate at which the animals consume oxygen. There is also a fall in body temperature.

Surgeons have tried to reduce the oxygen consumption of the body by cooling it before the start of a surgical operation. By so doing they hoped to reduce the shock effects. To make a success of this technique, it was obviously necessary to suppress the shivering reflex, which represents one facet of the body's normal reaction to lowered temperature. This suppression has been achieved in the past by deep anaesthesia or by the use of muscle relaxants—which, however, could be dangerous for the 'poor risk' patient.

Last year artificial hibernation was tried by two French doctors. Their technique involved the cooling of the unconscious patient by means of ice bags or refrigerated blankets. They suppressed the shivering reflex by previously injecting a combination of drugs which they called a 'lytic cocktail'. The key item in this 'cocktail' is a new drug, discovered in France and known as chlorpromazine. It has been introduced into this country, where it has been used in rather less elaborate mixtures than the French have used but with equally good results, it is claimed. The use of chlorpromazine makes it possible to lower the body temperature to as low as 28° C (82° F), without harm to the patient. By means of this 'artificial hibernation' method it has proved possible to operate on patients who otherwise could not have survived a surgical operation.

A typical example was a woman of 76 who was in

hospital for a tumour in the pelvic region. After admission her heartbeat became so irregular that she was quite certainly unfit for a conventional operation. As her condition deteriorated it was decided to resort to the artificial hibernation technique. She was successfully operated on, and she made an uninterrupted recovery.

It has already been found that physical cooling of the body is not really necessary as chlorpromazine—by blocking the action of the temperature-regulating centre in the brain—produces a fall in temperature of two or three degrees Fahrenheit, which is sufficient to lower the oxygen requirement considerably.

The technique is at the moment recognised as one not without hazard, and in the present state of knowledge it is held not to be justified unless there are special circumstances. In the hands of surgeons with a carefully calculated and cautious empirical approach this technique may be improved to the point when it can be more widely applied. It is possible, too, that the 'artificial hibernation' method might gain if more fundamental research could be done on the physiology of natural hibernation, an aspect of that very fascinating subject about which hardly anything is known at present. Few physiologists have studied natural hibernation, but a study of this phenomenon might well yield facts capable of medical application, quite apart from the purely scientific value of such an investigation.

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MORE ABOUT COAL PUMPING

Our last note on the pumping of coal (DISCOVERY, Feb. 1953, pp. 38–9) reviewed the basis for experimental work in this technique and showed the kind of speculations that were being made about its possibilities. In the past year a number of different ideas which were then being discussed have been followed up, particularly at the British Hydromechanics Research Association's laboratories at Harlow, Essex. The work has now reached the stage where the scale of operations is approaching the point of industrial application and, if the experiments being carried out at Harlow prove successful, they will be repeated on a bigger scale in a coal mine.

To reach this point, a carefully planned programme of research has been carried out to find out the properties of solid-liquid mixtures in flow. This was necessary since little theoretical knowledge existed on which practical applications could be based, although some forms of two-phase flow systems have been in industrial use for years—the water transport of gravel and pneumatic handling of grain are examples. The practical coal-pumping installations were first developed by trial and error and new propositions estimated on the basis of previous experience. This method is a quite common engineering technique but gives way in the course of time to an attempt to investigate the mechanisms involved on a scientific basis. The Research Association has done just this with the flow of liquids and solids together. The guiding lines in any work of this kind are to be found in the general principles of fluid dynamics. These have to give an answer to the designers' problems, which are to find the right size of pipelines to transport the required quantity for the most economical expenditure of power. Normally, low fluid speeds give low pressure losses and require less power. With solids in a fluid, however, the solids will separate out at low speeds and the fluid has to flow over the top in a constricted cross-section. The effect of increasing speed is to pick up the solids so that the régime changes to one of mixed flow with the fluid having something more like the whole cross-section to move through: this is shown by a series of photographs of small coal in a pipe through which water is flowing at successively higher speeds (Fig. 2). There are other problems of pressure drop where the pipe has to change direction or travel upwards. In the latter case the tendency of the denser solid to drop back against the stream must be taken care of by making the stream flow sufficiently fast.

Experimental work has been carried out with $1\frac{1}{2}$–3-inch pipes with coal of quite small size, around $\frac{1}{4}$–$\frac{1}{2}$ inch. The latest test rig which has been built will carry the investigation into the scale of possible practice with the use of 6-inch pipe. The rig erected at Harlow is shown in Fig. 1, and experiments are now in progress with it.

The Association suggests the most promising application of this work is in the transport of coal from pit bottom and calculates that an 18-inch pipe could handle 500 tons an hour of coal up to 6 inches in size. This stage has not yet been reached, one of the problems being to feed the coal into the pipeline against the pressure of the water which is to convey it. A machine to handle 50 tons an hour against 2000 feet has been constructed. This is the right kind of size for practical use, and results of the trials can be looked forward to with great interest.

THE GENIUS OF THOMAS YOUNG

What is genius? No satisfactory definition that embraces all examples has ever been formulated, but it is certain that genius is much more than occasional brilliance and something different from, though it may comprise, Carlyle's 'transcendent capacity for taking trouble'. Genius is always allied to high intelligence. It ranges adventurously in the realms of knowledge and speculation. It often raises the winds of controversy and always lifts the earth-bound with wings. Above all, genius *thrills*.

By these criteria—and they are but a few of the many aspects of a comprehensive definition—Thomas Young was a genius.

He was born at Milverton in Somerset in 1773, the son of Quaker parents. At the age of two he could read fluently, and before he was five he had memorised the whole of Goldsmith's *Deserted Village*. He started Latin before he was six.

His two main interests in life—science and languages—were conspicuous by the time he was thirteen. He had first been excited by physics when, at the age of eight, he came upon a *Dictionary of Arts and Sciences* and read it with delight. The usher at the school built on this interest and showed the boy how to use a lathe and make his own optical instruments. Before he was eighteen he had read Newton's *Principia* and *Opticks*, and books on chemistry by Lavoisier and Black. His use of lenses quickened his interest in the plants he came across, and so he added botany to his

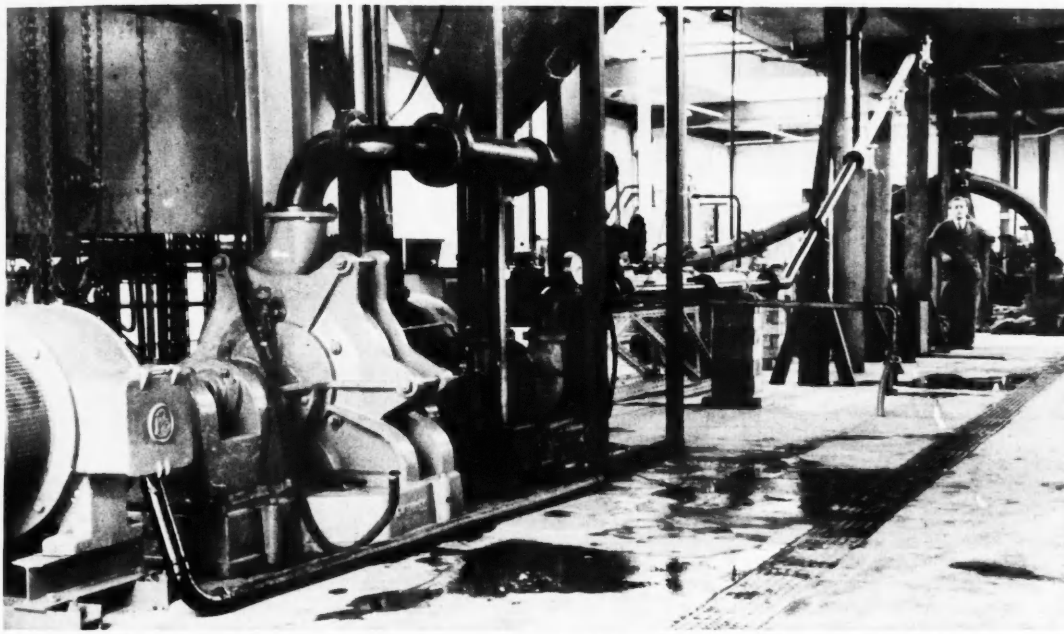
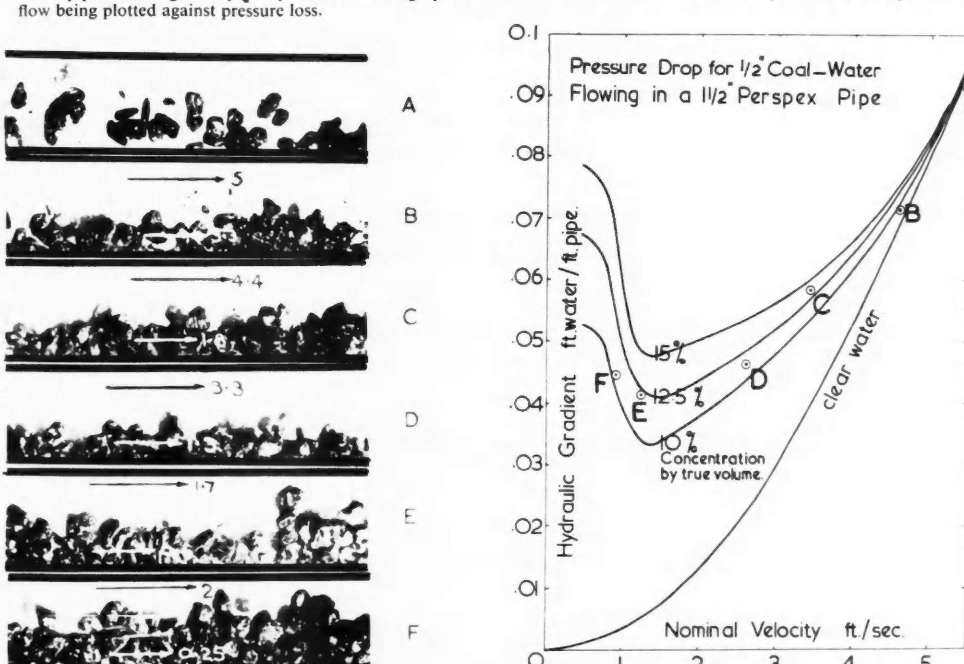


FIG. 1 (*above*). The 6-inch pilot-plant coal-pumping unit at the laboratories of the British Hydromechanics Research Association. A similar unit will soon be tried out at Markham Colliery, near Chesterfield.

FIG. 2 (*below*). Fluidisation of coal in a pipe depends on the speed of flow. In *A* there is a flow of 5 ft. per second, which gives complete mixing of the pieces of coal and the water. At lower speeds (see *B-F*) the coal falls out of suspension and moves at a much lower speed. In *F*, for example, the water is moving at 2 ft. per second, whereas the coal at the bottom of the pipe is moving at only ¼ ft. per second. The graph summarises the results of one series of experiments, the speed of flow being plotted against pressure loss.



studies. His interest in languages seems to have been innate; there is no evidence of any particular book or study acting as a trigger. At thirteen he had a pretty good knowledge of Greek, Latin, French, Italian, and Hebrew. He then left school and back at home he borrowed Hebrew, Chaldee, Syriac and Samaritan grammars. Later he went on to deepen and systematise his knowledge of the classic languages and develop an interest in many others.

Before he was twenty he had a paper read to the Royal Society on the accommodation of the human eye. He reasoned from his own observations on a dissected bullock's eye that accommodation was effected by changes in power of the eye lens. He was right, as we know, but when his paper was read there was no generally accepted explanation of the phenomenon of accommodation. This paper, written when he was a medical student in London, was followed by his election as an F.R.S. three days after his twenty-first birthday.

It is not perhaps generally realised that every one of Young's original discoveries and theories was the result of spare-time activity, for he was by profession a physician. He ran a practice in London and in Worthing (to cater for the summer visitors arriving there for the new-fangled sea-bathing) and was physician to St. George's Hospital from 1811 until his death in 1829. He tried hard to succeed as a doctor, even to the extent of refusing scientific commissions and cutting short a professorship, but from the point of view of the world—the number and importance of his clientèle—he was a failure, though everyone admitted his knowledge and skill. Apparently he lacked the bedside manner; he was interested in the science of medicine, not the patient. He himself admitted his own failure of his profession.

In his spare-time activities, it was a very different story. He produced paper after paper that opened up new subjects and introduced new techniques. In 1800 he read a paper to the Royal Society on the mechanism of the human eye, which Sir John Parsons has described as a masterly monograph. He described his optometer—a new invention for measuring the eye's accommodation—and in a series of elegant experiments (performed on himself, often with considerable pain and discomfort, though his rather prominent eyes helped) he laid the foundations of physiological optics. His own measurements of the eye dimensions differ very little from those which are accepted today.

The following year he delivered the Bakerian lecture to the Royal Society *On the Theory of Light and Colours.* In this he stated his belief that colour vision was the result of a triple mechanism in the eye. Half a century later Helmholtz revived the theory, and it has consequently been known ever since as the Young-Helmholtz trichromatic theory, which is still the most widely accepted theory.

From 1801 to 1803 Young was Professor of Natural Philosophy at the then newly-established Royal Institution. He considered lecturing the most important function of the Institution, and he gave one lecture every Friday evening, a custom still followed today. These Royal Institution lectures were eventually published. He was not a good lecturer, for he assumed too much knowledge on the part of his listeners and his manner was dry and his exposition often involved, but the amount of original material in them, and their intellectual standard and breadth of knowledge, were astonishing. Buried in these lectures, for example, is his account of elasticity, giving the expression *Young's Modulus* to every subsequent textbook on mechanics. Also in them is an account of geometrical optics, with a method of ray construction which is universally used today, and also a number of formulae that are still used by optical designers. It is probable that in the whole history of pedagogy there has never been a set of lectures intended for an instructional purpose yet containing so much original discovery.

At about this time he was developing his wave theory of light (against the then existing corpuscular theory) and very soon ran into controversy. He was a critical man with a Quaker forthrightness—though he had given up being a practising Quaker—and his teachers and his predecessors in discovery were subjected to acid comment. One of his criticisms of a contemporary led to the bitterest anti-Young tirade ever to appear. In 1798 a paper had been read to the Royal Society by a very young man, a few years younger than Young—Henry Brougham, afterwards Lord Chancellor and founder of London University. Young treated this paper with contempt in a magazine article, though without mentioning Brougham's name. That was in 1800. From then onwards he was busy with the wave theory, especially his explanation of interference, the colours of thin films, and so on. In 1802 the *Edinburgh Review* was started, and in it Brougham wrote three articles anonymously, all criticising Young's wave theory. Parts of the articles have often been quoted, such as the statement that Young's papers were 'destitute of every species of merit' and his theories mere 'lucubrations'. In the opinion of responsible people they so damaged Young's reputation that the truth of his theories was not examined for twenty years, and he himself was so hurt by the criticism that he gave up physics for some time.

This was not the only argument or controversy in which Young was involved. The dispute between him and Fresnel was never fully resolved because Fresnel died in the midst of it. At first they were friendly and appreciative of each other, but relations between the two men later deteriorated. There was the rivalry between Champollion and Young in Egyptology. Young in four years succeeded in doing what savants had failed to do in twelve, that was to decipher the demotic script of the Rosetta Stone and outline the key to the hieroglyphics, a key that really opened up the study of ancient Egypt. In fact Young was first in everything he touched, throwing out ideas later taken up—with or without acknowledgment—and amplified and made rigorous by others.

Thomas Young excited everyone who met him (with the possible exception of his Cambridge tutor, who evidently could not stand Young at all). He refused to stick to one subject. The whole surprising range of his activities in a fairly short life—he died in his fifty-sixth year—has demanded to be told in the light of modern knowledge. And so at last it has been. Dr. Alexander Wood spent many years on the necessary research work, which was for him a labour of love, but died after only ten chapters had been written. However, another Young-admirer, Frank Oldham, has completed it and the Cambridge University Press has just published it. All that remains to be done

Myxomatosis is proving a headache to the various ministries of agriculture in Europe, for it is now out of control and a serious menace to domestic rabbits. In Australia, on the other hand, the spread of the disease is still being actively encouraged by the Government; in that continent officials are disturbed at a falling off in the virulence of the virus, which is now proving only 90–95% lethal as against the original 99%. The Australians rely upon mosquitoes to carry the disease; for this reason carcasses of infected rabbits are left undisturbed.

perhaps is to republish Young's lectures on natural philosophy, in a shortened form, and use the book in sixth-form science teaching. The pupils would then not only learn a lot of fundamental physics; they would be rewarded by something more important than the facts—contact with the mind of a genius.

THE MYXOMATOSIS EPIDEMIC

Who introduced the virus which started the myxomatosis epidemic now raging in Britain? What is the black market price of myxomatosed rabbits in this country? Possibly the first question never will be answered, though in France it proved possible to identify the person responsible for starting the European epidemic; the answer to the second question it should not be difficult to obtain.

These two questions are prompted by the publication of the Government committee's report on the myxomatosis epidemic, coupled with information which we gained on a visit to the Pasteur Institute last month.

The French experts are quite certain that the spread of myxomatosis is being accelerated by the farmers. The rate of spread is far greater than one would expect if only insect vectors were involved. It is known that farmers intent on harnessing this disease to the destruction of the rabbits on their land are acquiring infected rabbits and introducing them into uninfected warrens. Quite a brisk trade in infected rabbits has grown up, and these are fetching about a thousand francs apiece on the black market. Such action is not approved by the French authorities.

The scientists of the Pasteur Institute are equally sure that the myxomatosis virus never crossed the English Channel by accident. They do not believe that it crossed the water in the bodies of insect vectors, and they think that myxomatosed rabbits must have been smuggled in.

The Pasteur Institute has now thoroughly investigated how this rabbit disease affects hares. In the wild a few hares have been found to be heavily infected with the virus; in these the symptoms of infection have been the same as in the rabbit, and the disease has proved fatal. But such cases are rare. The institute's virus experts then proceeded to see whether they could infect captive hares with the virus and so create the disease artificially. For this experiment a dozen or so hares were kept at the Pasteur Institute, and it proved possible to infect one of them. The rest proved to be resistant. The scientists summed up their observations on the hare's susceptibility in these words: "The hare is capable of contracting myxomatosis in its classic and lethal form; but there is no doubt that this is an exceptional event and that, in general, animals of this species are resistant to the virus of Sanarelli [the strain of myxomatosis virus involved]. The position of hares *vis-à-vis* myxomatosis appears to be the reverse of that of European rabbits: the former contract the disease only exceptionally, whereas the latter is only rarely resistant to it." (An account of this work by H. Jacotot, A. Vallee and B. Virat of the *Service de Microbiologie animale* of the Pasteur Institute was published in the *Annales de l'Institut Pasteur*, January 1954.)

It is therefore clear that the spread of the disease is not likely to upset the hare population of European countries, unless a new strain of virus arises by mutation. The French view is that the disease will have a greater affect on the fox population of the infected areas as the rabbits which represent one of the fox's main sources of food are dying in enormous numbers. It is thought that in Europe about 5% of the wild rabbits are resistant to myxomatosis, but it is considered too early to express an opinion as to whether the long-term effect of the epidemic will be a great reduction in the rabbit population or the replacement of a largely susceptible population by one that is immune to the myxomatosis virus. In Australia the percentage of resistant rabbits in the population appears to be increasing, with the effect that the killing power of the virus is diminishing.

FLIGHT 170 MILLION YEARS AGO

W. E. SWINTON, *Ph.D., F.R.S.E.*

During the Triassic Period there existed an interesting order of reptiles which were called the Thecodontia because their teeth fitted into sockets. Some of these were land-living creatures, superficially like little crocodiles in appearance, and with rows of little bony plates or scutes arranged along the back. What was more remarkable was that this particular group so characterised had developed the habit of running upon the hind limbs which were thus markedly better developed and greater in size than the fore limbs.

Most of the members of this particular group—the Pseudosuchia, or false crocodiles, as they are known—come from South Africa or the United States, but at least one important genus occurs in the north of Scotland, while others, which are rather less well known, have been found in England. A typical Pseudosuchian was small, perhaps only about three feet long, and of this length the tail might take up half. What then is the fundamental importance of so obscure a group of small reptiles of 200 million years ago?

These Thecodonts as a whole gave rise to the mighty and diverse reptiles known as the Dinosaurs, to the swimming reptiles we know as the Crocodiles, to the flying reptiles (Pterosaurs), and to the birds. On that showing alone they cannot be denied their place in history; their part on the land was important, in the sea it was less significant, but the progeny that took to the air were doubly interesting and were to multiply and survive for many millions of years.

The Pterosaurs, or 'winged lizards', is the more scientific title for those apparently awkward but intriguing creatures that are more widely and popularly known as Pterodactyls.

No trace of any Pterosaurian has yet been found in the Triassic rocks. The earliest specimens that have been uncovered are the British fossils called *Dimorphodon*. This creature was by no means the first flying reptile to be discovered, for German examples are almost ancient history, but the first British specimen was discovered in 1828 by Mary Anning, already the discoverer of the very first Plesiosaur and Ichthyosaur. *Dimorphodon* came from the Lower Liassic rocks of Lyme Regis which may be dated at approximately 170 million years old. This genus had a large but light skull nearly nine inches long, and having in the jaws large teeth in front and small teeth behind, from which feature the generic name is derived. The whole animal would be about three feet in length, with the tail accounting for more than half. It is interesting to note that in this, the earliest form so far known, lightness of build had already been achieved; the fore limbs were well developed, whereas the hind limbs were less robust. The skull shows that the brain must have been quite small. All these are facts of evolutionary interest, but before arguing this theme, the general picture of Pterodactyl flight must be discussed.

It is interesting to notice how often the air has appealed to the vertebrates. Every class of them has its aerial representative; in contrast to the fishes and the amphibians which have made but little use of this medium of transport, the reptiles had the Pterosaurs in the air for a hundred million years; the birds have been wonderfully successful; and among the mammals, the bats have simulated their aerial predecessors with some success. The primitive Pseudosuchian was, as has been said, already bipedal. The fore limbs were free, and Nature as well as the devil, may find work for idle hands to do. At any rate the hypothetical ancestor of the Pterodactyls and the birds, seems to have acquired considerable cursorial ability, which was reflected in the development of its lower limbs, and then to have taken to the trees, where the arboreal life not only gave some special facility to the hands but provided an opportunity for the practice of gliding. There is no positive evidence for all this, save what it is possible to deduce from the limbs. But perhaps the major result may have been a quickening of the metabolic rate. This is hard to prove, but there are few circumstances which require a greater co-ordination of hand and eye and general activity than an arboreal life, and among the few are the flying qualities, which in both the Pterosaurs and birds may well have followed the same general course. So far as the geological evidence is concerned the testimony is that the Pterosaurs achieved their objective first, for nearly 15 million years separate the Lower Lias rocks of Dorset and the Kimmeridgian of Solenhofen that yielded the first bird, *Archaeopteryx*.

Pterosaurs and birds share several features, and oddly enough this is best seen by comparing the Pterosaurs and the later birds. Both have pointed skulls with the bones fused; both primitively have teeth; both later lost their teeth and may have developed accessory structures. Both have the flying mechanism confined to and controlled by the fore limbs, though tails may play a part. Both *Dimorphodon* and other early Pterosaurs and *Archaeopteryx* had long tails, arguing an initial instability of flight that was to have powerful consequences. All later Pterosaurs and all birds have short tails. But the early Pterosaurs had a keeled sternum like the later birds; both also had hollow bones, whereas the bones of *Archaeopteryx* were solid structures. But the birds, even *Archaeopteryx*, had a far better flight mechanism. A series of feathers provides an air-resistant shield that is powerful and economical. Its composition allows partial movements, and accident to a part need not necessarily impair the whole. Contrast this with the web of skin (or *patagium*) in the modern bat; this is all in one piece but being supported by the separated fingers it shares some of the advantages of the bird wing. The patagium of the Pterosaur, however, was just a web of skin borne on an excessively developed finger and otherwise attached only to the side of tne oody and the thigh. This meant that there was no stiffening support within the patagium itself, and that there was a long, free and presumably almost paper-thin external edge. Modification of the elasticity of the wing could only be made by relative

movement of the arm and leg, and there might well be a tendency for the wing to tear; certainly any small amount of damage would quickly spread to the whole.

The wing was borne on the greatly elongated fourth finger. The first three fingers were well developed and normal in size at the wrist; the fourth finger went on to almost twice the length of the upper and lower arms together. Originally it was thought that the retracted thumb gave support to a small skin extension between the shoulder and the inner aspect of the wrist, but this bone—known as the pteroid—is not the thumb. The fifth finger is missing in all Pterosaurs but this kind of reduction is not uncommon in the group which is thought to have given origin to the flying reptiles.

Pterosaurian evolution reached its peak during the Jurassic, from which many interesting forms are known. These are all comparatively small, seldom larger than a duck and often as small as a sparrow or thrush. Yet the body was even smaller than the body of a similar sized bird, and the wings proportionally large, so that the weight of a living Pterodactyl must have been very little, often it would have been just an ounce or two. Part of this lightness was achieved by the hollowness of the bones, and these still show in section the extraordinarily thin outer walls and the internal struts that, none the less, kept them strong.

In contrast to the fore limbs, the hind limbs were underdeveloped and weak, so much so that one of the great problems about these reptiles is their method of movement. Older reconstructions were bolder and a flying reptile was often figured (as in Fig. 2 here) walking on all fours with the wings folded in umbrella-like fashion. It is almost certain that the structure or arrangement of the hind limbs would not permit this and it is also doubtful if the suggested swimming pose (see Fig. 3) was any more probable. It is generally assumed that the resting reptile used its hind limbs as do the bats, and hung upside down. On the whole, the nature of the teeth, the fact that nearly all skeletons have been found in marine deposits, and the underdevelopment of legs have combined to suggest that these animals lived on low cliffs and overhanging rocks from which they could launch themselves to use the wind pressure to sail over the seas and snatch a fish from the waters. If the wind were strong this picture is satisfactory enough for the launching, though an approach to the waves must have been hazardous for the safety of the delicate wing tip. On the other hand, on calm days, a Pterosaur that settled on the smooth sea would find it impossible to take off again.

No satisfactory solution to these problems is known apart from the major argument that the length of time that the order survived suggests that the individuals knew the answer.

Pterodactylus, a small tailless form, occurs in great numbers in the fine-grained lithographic limestones of Bavaria. Many of the specimens are of remarkable preservation, the outline of the little body being clearly marked. The presence of fine hairs has even been noted on one or two specimens, but the problems of classification that a hairy reptile would raise seem to be avoided by considering that the so-called hairs are in fact chemical markings around the decomposed body.

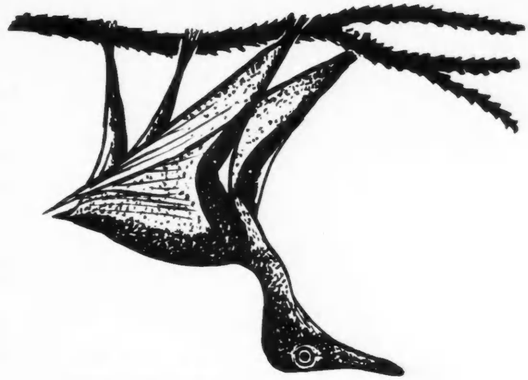


FIG. 1. Weak hind legs put the responsibility for movement and rest on the larger front legs. Here, with wings neatly folded, and using both hands and feet in perching, *Pterodactylus* is seen resting upside down on a branch.

FIG. 2. *Pterodactylus* using all four limbs in normal walking.

FIG. 3. Pterodactyls must often have landed on water. The reconstruction shows a possible method of swimming.

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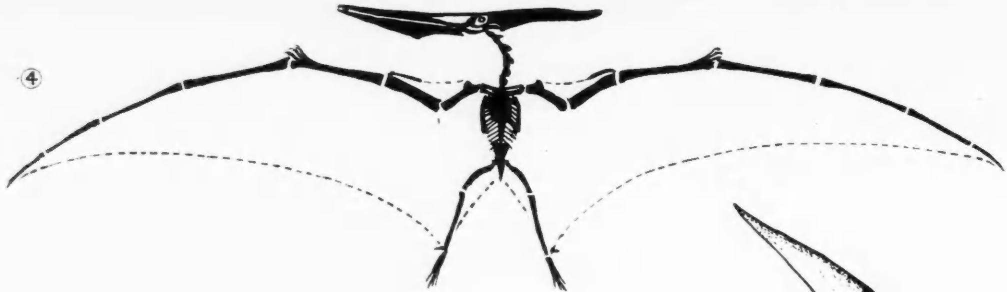

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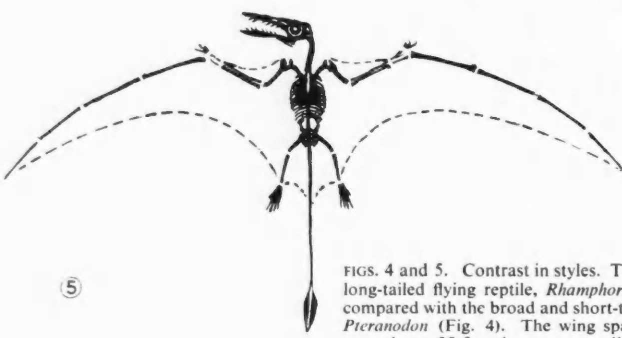

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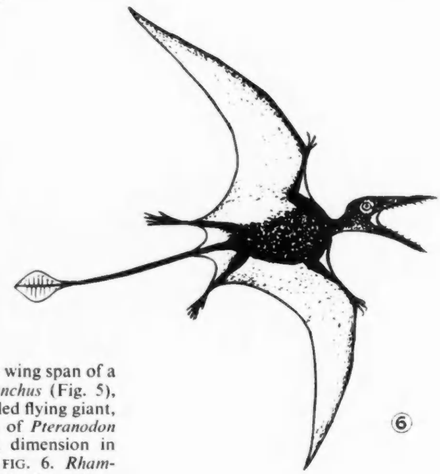

FIGS. 4 and 5. Contrast in styles. The wing span of a long-tailed flying reptile, *Rhamphorhynchus* (Fig. 5), compared with the broad and short-tailed flying giant, *Pteranodon* (Fig. 4). The wing span of *Pteranodon* was about 25 ft.: the corresponding dimension in *Rhamphorhynchus* was only $1\frac{1}{2}$–2 ft. FIG. 6. *Rhamphorhynchus* in flight showing the vertical rudder plane.

Rhamphorhynchus, another German Jurassic form, was, in some ways an improved model. It was larger and might be over two feet in wing span but it had a stiff tail with a vertical diamond-shaped tail fin at the end.

When the hundreds of these two kinds were flying over the great inland sea of Germany they had to share the air with the first of their new rivals, the birds. What the details of their conflict might be we cannot say, and the immediate outcome of their rivalry is not disclosed. The chapter of history that Solenhofen enshrines is an isolated one without beginning and without end, a fact that may appear rather obvious but is sometimes overlooked.

In Cretaceous times we have the evidence of the Gault and Chalk deposits of Kent, and the richer records of the Kansas Chalk. From them we learn that *Pterodactylus* and *Rhamphorhynchus* were no more but their place had been taken by the great *Ornithocheirus* and the even greater *Pteranodon*. These two genera have much in common, especially the delicacy and strength of their hollow bones. But whereas *Ornithocheirus* of England had teeth the long and tapering jaws of the American *Pteranodon* were toothless.

Pteranodon had sharply pointed jaws counterbalanced by a long bony process behind. Its breastbone was short, broad and keeled, and the shoulder-blade was firmly attached on each side to give a firmer foundation on which the wing could work. The wing span was as much as twenty-five feet. Broad and short, these great albatrosses of the past must have soared over the Mesozoic seas, preying upon and observing forms that like themselves were soon to be history Their weight must have been a matter of a few pounds but their dropping velocity would be about 30 knots at the water's surface. Strangely enough, their fossil record is greater than that of their rivals the birds. Cretaceous birds are indeed known, but they are few in number and at least one of them had abandoned the air for the sea. This last refuge was denied the Pterosaurs for they were fitted for one kind of life only and were too much encumbered for a return to either the ground or the water.

The extinction of the flying reptiles is bound up with many things and was probably not due entirely to the success of the birds. It is often said that they could not face the competition of these more efficient and warm-blooded newcomers, but there is perhaps some evidence that the Pterosaurs were partially warm-blooded. Certainly the competition was of long duration for of the 100 million years that the flying reptiles endured, the birds were with them for at least three-quarters of the time. During that long period the reptilian brain advanced along much the same lines as did that of the bird; their economies need not have clashed. There are evidences in *Pteranodon* that an ancient stock had had its day, but the often-made claim that in the fossil reptiles brawn outran brain cannot be substantiated here. Both birds and Pterosaurs had developed wings from front legs, and the birds may well have persisted because they retained their hind legs as walking structures too.

There is a strange parallelism between these creatures of the past and the aviation of today. We have seen the small, broad planes of the past; the long, heavily tailed models of the first days of air liners. Now the designers have turned to the broad and delta wing and the almost tailless types. In aircraft design we can say that the days of the Pterodactyl and *Rhamphorhynchus* are over; and *Pteranodon* is again in the sky.

A LINK WITH PREHISTORY

SIDNEY ROGERSON

Today U.S. servicemen and women stand in the shadow of history in many foreign countries. They are stationed alongside historic monuments or buildings and witness the survival of ancient rites and festivals. Only in one place so far as I know are they in touch with *pre*history and that is in eastern England where they can literally rub shoulders with men still practising a craft which links these days of jet-planes and atomic energy with the world of primitive man thousands of years before a word of history was written.

Ten miles from the big U.S. Air Force base at Lakenheath, Suffolk, is the small town of Brandon. Here men are still 'knapping' or chipping flint stones to fashion them into weapons of the chase or domestic tools. They can for example strike off a flint arrowhead or axehead, or a knife or scraper indistinguishable to the layman from the same object made by Neolithic man 10,000 years ago, and specimens of which can still be found in gravel pits or rabbit burrows. Not only has this craft of the knapper been passed on from man to man down the centuries but his method of quarrying the flint, his vocabulary and his system of counting all bear the mark of ancient origins.

Here it is necessary to digress by way of explanation. At one stage of the world's history the flat countryside around Brandon was under water, the bed of a sea which even in historic times, no more than 300 years ago, came so close to the town that the sturdy church tower carried a beacon ready for lighting as a guide to storm-tossed mariners. Drainage and land reclamation have pushed the sea back 30 miles, but in January 1953 the waters once again reasserted themselves, breached the man-made defences and again threatened the district over which they once ruled.

To revert, in the deep sand and chalk of this sea-bed run broad sheets of flint—an opaque, blue-black variety of quartz formed from the remains of diatoms or sponges which once swam in the prehistoric seas and, dying, sank to the sea-bed to become fossilised as flint. These belts or layers occur some 20–30 ft. underground and are a succession of separate lumps varying in size and shape and each encrusted in a skin of white chalk. There are six layers. The top is known in the knapper's language as 'horns' and is followed by the 'top-stone', the 'wall-stone' and the 'upper-crust', until the fifth layer or 'floorstone' is reached. This is the best accessible type of flint, and flint supplied prehistoric man with the weapons and tools with which he fought, killed and prepared his food, and finally with which he dressed and even sewed the skins which were his clothes. Because the Brandon area was so rich in flint—and flint of such excellent quality, so readily converted to man's use—Brandon became the centre of what passed for industry in prehistoric times. It was at once the arsenal of prehistoric England, sending flint weapons all over the country, and it was also the producer and distributor of its domestic hardware. Indeed the importance of Grimes Graves in the ancient scheme of things was startlingly emphasised only last year, when a British scientist who had been working for years on the mystery of certain large stones which he had noted in the area around London announced his findings. These stones were made of pebbles embedded in sandstone (conglomerate) and looked like puddings full of raisins. What puzzled the scientist was that they appeared in areas where there was no conglomerate. For over three years he tracked down these 'pudding stones', as they were called, and last summer was able to announce that they formed a trail leading from the valley of the River Thames to Grimes Graves. His theory is that the primitive 'knappers' of 6000 years ago laid a trail of 'pudding stones' to guide people to the centre of their flint mining industry. Although the trail has been lost west of London, it is not impossible that it once extended to the south coast and was laid to guide the visitor from Europe as well as the natives of Britain.

If prehistoric man could not have lived without flint, neither could his successors in historic times. As man mastered the art of working in metals, he had no use for crude stone weapons and tools, but flint has another important property. If struck with steel it produces a spark. Throughout the centuries flint has been the begetter of fire. Indeed until 1838 the striking of flint on steel was the only means to make fire or ignite gunpowder. So civilisation in peace or war depended on flint almost as much as had primitive man. And because the blue-black 'floorstone' from the Brandon district was most productive of sparks, flints made from it continued to be distributed throughout England. Thus it came about that Brandon remained the centre of flint quarrying, and this explains how the craft of prehistoric man has been perpetuated into the age of nuclear fission.

It may be significant that this has been due to the value of flint for lethal rather than domestic purposes, to flintlocks in pistol, musket or cannon than to flints for tinderboxes. It is true that throughout the Dark and Middle Ages the flint workers of Brandon must have sent their products all over the country to bring light and warmth into the homes of Saxons and Normans, to the castle of the nobleman and the hut of the serf, while from the beginning of history Brandon was famous for the skill of its flint workers as builders of flint walls. As early as the 12th century men from Brandon travelled far afield to give expert advice or assistance in the building of church and cathedral. For all that it was the introduction of the flintlock in weapons about the middle of the 17th century which raised Brandon for a brief period to a pinnacle of fame which must be unparalleled in so small and undistinguished a hamlet.

For nearly two centuries—covering the period when Britain was laying the foundations of her Empire—Brandon was the sole source of supply of flints without which the weapons of her armies and navies could not be fired. It is an astonishing reflexion that for so long a time the defence of the nation and its ability to make war should have been dependent on the energies and skill of a handful of men grubbing in the chalk of eastern England.

These 200 years were the years of Brandon's greatness.

FIG. 1. Grimes Graves: the photograph shows entrances to three galleries leading from one of the main shafts.

Every week a sale of flints was held in the market-place and was attended by Government procurers and contractors who had to lumber down the ninety-odd miles from London either in their heavy coaches or on horseback. Brandon held the contracts for supplying not only the British Army and Navy, but also that great builder of British power in India, the East India Company. Yet even at the peak of its importance this key industry never employed more than two hundred men.

About the year 1850 the development of new types of firearms into the European and British armies cut down at one blow the demand for flints. In Oriental armies the flint-lock remained in use for a few years longer, but the last big order for gun-flints was one for eleven million carbine flints for Turkey during the Crimean War of 1854–5. Then ensued the closing stages of the world's oldest industry. As the flints were succeeded by the percussion-cap in the armies of the world, they were thrown on the commercial market, bought up by merchant firms and traded to savage or semi-civilised peoples throughout the world. Since the life of a gun-flint is short—the best flint will only serve about a hundred shots—the Brandon knappers were kept reasonably busy and prosperous, supplying export houses trading with Central and West Africa, Indonesia and Borneo. But this civilian trade was destined to be destroyed by World Wars I and II which not only familiarised peoples in the world's most remote places with modern weapons, but left them in possession of embarrassing quantities of them. The Dyaks of Borneo had no further use for flint-lock muskets when they could have Garand or Japanese rifles left behind as a result of the war in the Pacific. After World War I Brandon flint-knapping shrank so sadly that whereas at the turn of the present century 500,000 flints were being turned out a week, it was a rare thing between wars for the total to exceed 40,000. Even before war came again in 1939 the industry had virtually ceased to exist as an industry. But if flints were no longer knapped against a commercial demand, they continued to be produced as souvenirs for tourists and visitors. So the craft remained and has remained to connect young U.S. pilots, mechanics of Sabres and Superfortresses with the little folk who in the mists of prehistory lived and fought and had their being in the sandy, bracken-covered wastes where mile-long tarmac runways now stretch.

These primitive people have left abundant evidence of their search for flint in the shape of the quarries or pits they dug. At Grimes Graves—no one has been able to explain this name—two miles from Brandon no fewer than 346 of these prehistoric pit quarries have been identified over an area of 35 acres. Two of them have recently been expertly excavated and are now preserved by the British Government as ancient monuments. They are about 30 ft. in depth and 15–20 ft. in diameter. At the bottom, openings lead to galleries radiating in all directions as the diggers went after the 'floorstone'. Some of these galleries have been traced as far as 60 ft. and have been found to connect with five other pits within 20 yds. of the main excavated shaft.

The impressive thing about Grimes Graves is that these numerous pits, representing a concentration of activity considerable even by the standards of historical times, all had to be dug with no other discernible tools than stag-horns—the antlers of a large species of deer, many well-worn specimens of which have been found in the workings. The place has to be seen before any adequate idea can be formed of the stupendous labour which prehistoric man expended to win the vital flint from the earth. In historical times and up to World War II the knappers quarried their raw material on the common land at Lingheath, nearer to Brandon, where the townsfolk have the right of digging for flint, but where their methods of quarrying are, if anything, more rudimentary than those once practised at Grimes Graves. The digger first makes a shallow grave-like hole about 8 ft. by 3 ft. and 4 ft. in depth, in the centre of which he sinks a shaft down another 5 ft. He then excavates horizontally for a few feet and sinks another 5-ft. shaft, and by so doing, starts a series of steps which he continues to make till he reaches the flint-bed, when he burrows horizontally in all directions exactly as did his prehistoric prototypes.

Although he orientates the mouth of his shaft so that it shall receive the greatest possible amount of light during the day, the quarryman is obviously compelled to rely on artificial light. Here again there is evidence of that extraordinary continuity with prehistory. The excavators of Grimes Graves discovered several rude chalk receptacles which, filled with animal fat as fuel and moss as wick, had served as lights for the ancient digger. The modern flint

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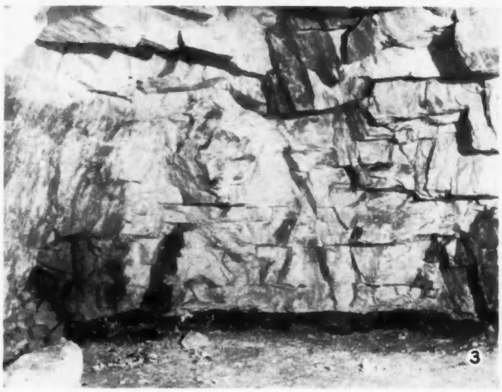

FIG. 2. Typical Breckland vegetation covers the flint mines of Grimes Graves.

FIG. 3. View showing the seam of flint at floor level.

FIG. 4 Aerial photograph of Grimes Graves. (*Reproduced by permission of the Air Ministry and the University Committee for Aerial Photography. Crown Copyright photograph by J. K. St. Joseph.*)

FIG. 5. One of the galleries at Grimes Graves.

(All except Fig. 4 are by Hallam Ashley.)

quarrier makes himself exactly the same sort of chalk candlestick: the sole difference being that instead of having to rely on moss and fat, he can buy himself a candle. Having prised a blue-black lump of flint out of the chalk with pick and crowbar (instead of staghorn) the quarryman faces the problem of raising it to the surface. These lumps weigh from 2-16 st., but they are hoisted without either rope or pulley. The digger just lifts the lump and leans back against the wall of his shaft until he can rest the flint on his chest. Altering the position of his hands he brings the stone to the top of his head and then by a quick jerk on to the lowest step of his shaft. He then climbs up himself and repeats the process until he and his load arrive laboriously at ground level.

When sufficient stones have been raised they are carted off to the 'knapper'. Sitting in his workshop, a shed maybe in his little garden among his flowers and vegetables, the knapper picks a lump of flint, places it on his knee, which is protected by a leather pad, and then strikes it with a heavy hammer, breaking it into pieces about 6 in. square. This is known as 'quartering', the art in which lies in splitting the stone so as to leave a square edge from which to begin the next process which is called 'flaking'. This is a very difficult operation, a high degree of proficiency being required to strike the stone on the proper spot, at the proper angle, and with the proper force. The final stage is 'knapping', when the long knife-edged flakes are knapped or chipped into the size or shapes required. For this process the knapper sits at a block in which is fixed a short iron stake padded with leather. Holding the flake face uppermost on this stake the knapper trims it into shape with a hammer made from a flat file. The average number of flints knapped per hour is around 350, though a first-class knapper will turn out as many as 500. The weekly output for one man ranges between 10,000 and 12,000

I have spoken of flint-knapping in the present tense, but the truth is rather that though men still remain who are adepts at it, they practise it more as a parade of skill than for reasons of commerce. And sadder still, their numbers are now reduced to two. With the disappearance of this pitiful rearguard will disappear not only the link with the Stone Age but also, unless active steps are taken to perpetuate them, as the Government has accepted responsibility for the preservation of Grimes Graves, the trade language and method of counting, which must be almost as old as the craft itself.

Not surprisingly the knapper is not a literate type. Right up to World War II, despite the pressure of State education, a percentage of the craftsmen could neither read nor write. Their speech was in the broadest dialect and interlarded with words whose origin is entirely lost. For example a pile of flints waiting to be carted to the knapper was known as 'jags', a pillar of chalk left to uphold the roof of one of the workings is called a 'jarm', a layer of flint a 'sase'; while the quarrying of a sloping passage from one layer to another rejoiced in the curious title of 'bubber hutching on the sosh'.

More remarkable still is the knapper's method of rendering his accounts. Being illiterate, he yet evolved a most simple but ingenious method of counting his flints and rendering his bills in terms of money. Yet the only conventional numeral he could write was a 7, because it is shaped like the pick which was his stock in trade. His other numerals are combinations of the three elementary symbols X, I, –. Now X = 1000, I = one, or, if following the X symbol, 100; – = one-half, whether of 1000, 100 or any other number. Thus if the knapper wished to write that he has completed 1250 flints, he writes XII–. If this total is 2750, then he writes XX7–; if it is only 350, III–. The numeral 5 is represented by four uprights and one diagonal 𝍸. Consequently a total of 1875 would be written XIIIIIIII7𝍸. Once again the link with prehistory is evident. It is accepted that the method of counting used by the diggers at Grimes Graves and elsewhere was based on the human hand, four fingers and a thumb represented roughly as . It is no long step from this sign to the symbol 𝍸. Indeed, in the knappers' accountancy, the X is the sole witness to the civilisation which reached Britain from Rome.

When it comes to submitting a bill in terms of money the same system is used, though the symbols are slightly different. The knapper uses the three headings of pounds, shillings and pence. The sign for one pound sterling is a circle, thus O. Ten shillings, being half a pound, is ϴ. A penny is an upright I, and a halfpenny, the half sign –. In the case of money the sign X (because such sums as £1000 were quite unheard of!) equals 10. Consequently if you received from your knapper an account for XII.ϴ.IIII–, you would decipher it as £12 10*s.* 4½*d.* If on the other hand you got OOO.IIII.7, you would read it as £3 4*s.* 7*d.*

Even before the war these methods of reckoning were obsolete in practice and survived only in the memories of the older men. I noted them down from one Snare, and those interested in historical continuity might like to know that Snare was a name in flint-working as early as the eleventh century when records were first kept! They die hard, these old names!

What the modern visitors from the Western Hemisphere are witnessing, did they but recognise it, is the death-coma of the world's oldest trade. Perhaps it is fitting that this should be so since this is an age of revolution when old things are being pushed aside and succeeded ever more drastically by the new. Even before the last knapper is laid to rest in the cold, modern cemetery which has grown up in all its lapidary harshness alongside the old moss-grown churchyard, much of the breckland which gave his forbears employment and the necessities of life back to the dawn of time will lie under tarmac or forest; the first for the aerodromes, U.S. and British, which are growing up in this region under the threat of World War III, and the latter owing to the afforestation schemes decreed by the British Government to make good the losses in timber caused by excessive tree-felling to meet the exigencies of World War I and World War II.

Grimes Graves is in the care of the Ministry of Works, which organised the publication of a full illustrated guide to this 'ancient monument': however this guide, which was written by the late J. Reidmoir *is now out of print.*

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FIG. 1. Photomicrograph of a False Scorpion of the species *Roncus lubricum.* (*Picture by Arthur Barron.*)

SCORPIONS IN BRITAIN

THEODORE H. SAVORY

M.A., F.Z.S.

Of course they are not real scorpions, though they are not very different from the venomous creatures that are so formidable in hotter countries. Venomous indeed they are, able to kill their prey with a single blow, but not formidable, for they lack the mobile tail and the questing sting. Also they are very small, being less than three millimetres long. They are the *False-scorpions.*

Zoologists call them Chelonethi or Chernetes, and put them into an order in the class (Arachnida) which also includes spiders, harvestmen, scorpions and mites. There are scarcely a thousand of them in the world, and in Britain there are only a couple of dozen species. Unfortunately, many people never see one.

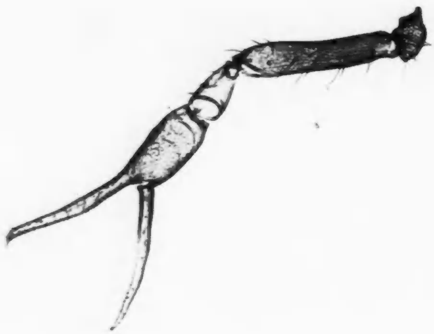
Aristotle knew them, or at least he knew one of them, and wrote, "In books other small animals are found, some of which are like scorpions without tails"; and in this country Robert Hooke in 1664 drew a picture of possibly the same species in his famous book *Micrographia.* They were at one time known as 'book-scorpions', because one or two species sometimes live on the shelves of old libraries.

The best way to get to know them, or some of them, is to take a sieve into a wood, a dry ditch or a sunken lane, and to sift handfuls of fallen leaves over a sheet of newspaper. A shower of small animals descends—and with a reasonable degree of good luck there will be a False-scorpion or two among them. At first they are not conspicuous, for they draw in their limbs and keep still; then, after perhaps half a minute, they begin to stir. They stretch their legs, spread out their enormous pedipalps, which they hold in front of themselves like the antennae of an insect, and move slowly across the paper with an air of impressive dignity and calm deliberation which distinguishes them from any other living thing on the sheet. It betrays them at once to the onlooker, and it reveals them as creatures of originality and of great fascination.

Perhaps as they thus proceed they meet some other animal, touching it, ever so lightly, with one of the long setae or hairlike bristles on their extended pedipalps. The action is instantaneous: the palps are withdrawn and the scorpion darts backwards with a speed tha is almost incredible to one who has just been looking at its majestic progress. This sudden retreat, reminiscent of the startled crayfish, is highly characteristic; not many animals can go backwards as easily as forwards and very few can go backwards so much more rapidly. I have seen them run for 3 or 4 inches, and with their indrawn palps they do not look like False-scorpions at all.

Clearly, small animals like these, living obscure lives in a dim light, are not easily studied in their natural surroundings. Their habits must be watched in captivity, which means that they must be brought home to the laboratory and kept in suitable 'cages'.

To do this successfully, the essential condition is a damp atmosphere. The biology books tell us that the advantage



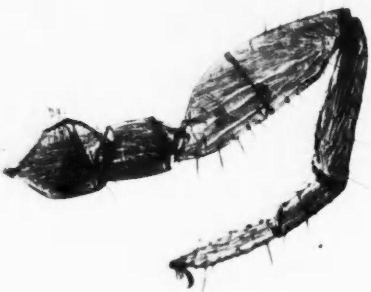


FIG. 2 (*left*). The pedipalp of the False Scorpion Chthonius *orthodactylus*, with its claw open. FIG. 3 (*right*). Leg of *Neobisium muscorum*. (*Photos by Flatters and Garnett.*)

of an exoskeleton of chitin is that it conserves the moisture of the body-tissues and prevents the animal from drying up. Perhaps it does do this, efficiently, for cockroaches, crickets and firebrats, which live only in hot places; it certainly does not do so for False-scorpions, as anyone will discover if he leaves one of them in a match-box overnight. A suitable container for temporary use is a covered glass dish, like a crystallising or Petri dish, with two or three wet filter papers on the bottom. For longer periods it is more satisfactory to cover the bottom of the dish with fine gravel such as is used in aquaria and on top of this to sprinkle a compact layer of silver sand. The gravel can be kept wet, and the sand makes a light background against which the behaviour of the animals can be easily seen. A few small stones will provide them with the shelter they seem to prefer, and in these conditions False-scorpions will live for weeks in apparent comfort.

They must be adequately fed. Unlike spiders, which fight and eat each other, False-scorpions are not usually cannibals if other food is available, though an injured or an ailing individual has a poor chance of survival. When first I began to watch False-scorpions I hoped that, like the harvest-spiders I had just abandoned, they would eat bread and butter, meat or fat or other contributions from the dinner-table. This was one of the features which made harvestmen so easy to keep, but my False-scorpions were a disappointment; they refused anything that was not alive. I sifted again some of the leaves among which they had formerly lived, and offered them anything that seemed to be small enough to be eaten. They fell upon the spring-tails, *Orchesella cincta*, killing them instantly before they had time to leap away, and consumed them completely. This was a surprise: even spiders, which have a reputation for voracity, leave fragments of their meals, but of a False-scorpion's victim there is found no trace.

This necessity for living food makes False-scorpions rather a trouble to keep, but it should not be supposed that each animal has, like a puppy, to be fed several times a day. Only the young ones need a daily meal. Dr. H. Levi, who studies these creatures in Wisconsin, finds that adults fed once a week seem to be in better condition than those to be caught in the woods.

After a meal a False-scorpion can often be seen to clean its mouth-parts and chelicerae. This habit it shares with spiders and harvestmen, which similarly pass their palps or their legs through their jaws. The mouth-parts of False-scorpions are a complex arrangement, able to eject secretions into the body of the prey, which is digested externally, and then sucked in as a solution. The organs involved possess several channels and grooves which must be kept free from solid particles. When a False-scorpion does this, it looks very much as if it were cleaning its pedipalps by combing them with its chelicerae, but actually the operation is working the other way round; not only are the pedipalps often dirty and allowed to remain so, but careful observation of spiders when they are doing the same thing makes it clear enough that the cleansing of the chelicerae is the important result.

In addition to this, False-scorpions are remarkable in that they also clean their chelicerae *before* a meal, and Mr. Owen Gilbert says that they do this when the presence of their prey is perceived.

The life-history of False-scorpions is imperfectly known, but the intriguing glimpses that have rewarded the patience of a rather small band of observers suggest that at the moment there can be few subjects in natural history which promise greater rewards for the study they emphatically deserve.

Male and female False-scorpions greet each other enthusiastically when they meet. The male grasps the female with his great pedipalps, and, more literally than usual, leads her a dance. After some minutes of advance and retreat he deposits a rod-like spermatophore on the ground and leads or guides her over it, so that it enters her abdomen. It is difficult to find a parallel to this remarkable method of fertilisation, but perhaps the most interesting problem is that suggested by the mere existence of such an elaborate method of courtship. What is it all for? Students of spiders have seen and described many examples of the elaborate dances in which the sexes indulge at this time, and have decided that these displays are of value to the male—who begins them—because they inhibit the female's ferocity by announcing the male's arrival and expressing his intentions. Thus they save his life, at least until its purpose has

been achieved. Such an explanation is not possible in the case of False-scorpions, where neither sex runs any risk from the other.

The abdomen of the female swells considerably as the eggs ripen within it, and this is to be attributed in part to her increased appetite. A few hours before the eggs are laid, an incubation chamber or brood-sac makes its appearance; it looks like a minute mushroom, its stalk joined to the oviduct, and the eggs are laid into it. Their number varies from five to forty.

After a few days the young escape from the egg-membrane but remain inside the brood-sac, attached by their peculiar 'sucking-beaks' to the oviduct of their mother and imbibing from her a nutrient fluid, 'uterine milk'. This makes them swell as if they had been inflated; Dr. Max Vachon of Paris describes them as 'larves gonflées'. Soon they break away, complete the casting of the skin which they had partially accomplished when leaving the egg, and emerge as protonymphs.

In some species the protonymphs ride on their mothers' backs like young wolf-spiders, but they are active and greedy little creatures, casting their skins at intervals to become in turn deutonymphs, tritonymphs and adults. There are no differences between the young stages save in number of setae on the limbs.

For moulting most False-scorpions appear to spin themselves a protective chamber, although cases of moulting in the open have been recorded in captivity. The animal remains quite still and a split runs round the edge of the carapace, which suddenly rises as if pushed from within. The skin of the abdomen seems to slide off backwards, with little help from the animal, and the legs are extracted much more easily than are the legs of spiders. After the moult a resting period follows; the recently-moulted False-scorpion is white but later becomes greenish and finally its normal brown. The microscope reveals the astonishing beauty of their small bodies; indeed from all points of view they have a quite unusual fascination.

THE PHYSICAL SOCIETY EXHIBITION

The particularly topical interest of this year's Physical Society Exhibition lay in the numerous items connected with nuclear physics, or nucleonics as it is now so commonly called. Not only is there an extensive programme of research in the universities and the atomic energy establishments, all of which demands its own novel sort of instrumentation; there is in addition an entirely new British industry, created in a bare eight years, bound up with the peaceful uses of nuclear fission and artificial radioactivity. There was on show a big range of devices for the detection, measurement and counting of fundamental particles and nuclear radiation—Geiger and scintillation counters and ionisation chambers, with their associated electronic amplifying and counting circuits and registering dials.

Much progress has been made with the scintillation counter, which depends on a phenomenon known and used half a century ago but only recently developed to provide an accurate and reliable measuring technique that is so sensitive that it can be used for prospecting for uranium, even aerial prospecting.

The uses of radioactive isotopes in industry are ever on the increase. One widely used method of measuring thickness (e.g. the thickness of tin in tinplate) depends on the fact that the absorption of radiation by an object depends on its thickness. Thickness meters, which utilise the beta emission of such radioactive substances as Thorium 90, are coming into wider and wider use in connexion with the manufacture of thin materials in a continuous roll or strip. An ingenious variant on the thickness meter, which was invented in Britain and is now being tried out in America, is a machine for measuring (and controlling by feedback) the amount of tobacco in a cigarette to an accuracy of one per cent. Yet another variant, utilising alpha radiation, is an automatic smoke—or fume—detector which should prove especially useful in places where fire might spread for some time undetected. This is of Swiss origin but is now being manufactured in Britain. (Such a smoke detector has been installed at the Fitzwilliam Museum, Cambridge, on the recommendation of the Cavendish Laboratory.)

Two devices developed at Harwell deserve special mention. One is a pump for pumping liquid metals such as mercury and liquid sodium (which has been suggested as a heat-transfer material for a fast reactor). The principle of this pump is a matter of unbelievably simple physics and as old as Faraday! If an electric current passes through the liquid metal—a good conductor—in a magnetic field, the conductor—which is the liquid itself—*moves*. No moving parts or valves are needed in such a pump, the casing of which can be made of a metal of very high melting point.

The second device is for the safety of those who have to work with certain materials as beryllium. Beryllium is a most toxic element: a trace of it—2 micrograms per cubic metre of air—is dangerous. Yet it is a metal essential for progress in the engineering of atomic piles. A machine has been developed which continuously monitors the atmosphere of a workshop in order to detect beryllium. Air is continuously drawn in and sparked between copper electrodes. Some of the characteristic spectrum of beryllium is selected by grating diffraction and passed through a slit, there to be detected by a photocell and amplified by an electron-multiplier thermionic valve. The resulting current variations are shown continuously on a chart, and it is thus possible to keep constant check on the amount of beryllium which has got into the atmosphere of the workshop. It is believed that this apparatus could be adapted to detect silicon in the air of coal-mines.

Another modern trend well in evidence at the exhibition was that of higher and higher speeds in photography. These are needed for the analysis of explosions and flames. One way of getting high speed is to do without a mechanical shutter. This can be achieved by changing the rotation of the plane of polarisation of light traversing a Kerr cell.

Such a change can be effected electronically and therefore at great speed. A drum camera has been evolved to make use of this Kerr-cell shutter. When first shown at a Physical Society exhibition (see DISCOVERY, June 1951, p. 170), the instrument was not even in working prototype. Since then this camera has been considerably developed and used. The Mark II model has an exposure time of twenty thousandths of a microsecond.

The Kerr-cell type of high-speed camera demands a high intrinsic luminance of the object being photographed, because the aperture is very small. No such limitation exists with the radically new sort of high-speed photography invented by J. Courtenay-Pratt of the Department of Physical Chemistry at Cambridge, who demonstrated it at this year's exhibition. The basis of this system is that a photograph is made via a lenticular plate (i.e. one with a grid of tiny lenses on the front), the photographic plate being behind. A camera lens acts in the normal way to produce the image that falls on the lenticular plate. The resulting photographic image is made of dots, rather like the picture given by a coarse half-tone printing process. If the spacing of these dots is enough (and this depends on the size of each tiny lens on the plate surface) a second photograph can be produced on the same emulsion displaced sideways from the position of the first photographic image. So can a third, fourth, fifth, sixth photograph and so on; the number depends on the spacing of the dots in comparison with their size. To achieve the succession of images, the plate *or* the main lens *or* the aperture must be moved sideways; only a very small movement is necessary, the distance involved being much smaller than the width of the plate. The possible sequence-speed of photographs is thus high. Each photograph can be printed separately if desired. In the apparatus demonstrated a Nipkow disc was used to produce a succession of displacements of aperture. Up to 50,000 exposures a second can be made with this camera. Other forms can, it is claimed, get as many as a million photographs a second.

ULTRASONIC DEVELOPMENTS

The possibilities of ultrasonic vibrations are still being vigorously explored judging from this year's exhibition. Kelvin & Hughes showed their newest development in echo-sounders for use in commercial fishing, a model incorporating a cathode-ray tube, as well as their flow-detector, an application also demonstrated by Glass Developments Ltd.

Mullard now have their ultrasonic drill in production form. The principle of it is not that of the usual rotary cutting; it is that of repeated hammering with a hammer that taps at a very high frequency—15,000 cycles per second—which for many people, as was evident at the exhibition, is not quite *ultra*sonic. The 'bit' for such drilling can have any cross-sectional shape—it can be shaped like a star, for example, or a letter of the alphabet. This bit is hammered against abrasive on the surface of the object to be drilled. In a few minutes a clean hole is produced; its shape can be varied by altering the shape of the bit, an important advance for hitherto it has only been possible to drill *round* holes. The drill can tackle any hard material however brittle.

Mullard also exhibited ultrasonic cleaning, which depends on the ultra-rapid agitation of a cleaning fluid in which an object to be cleaned is put. The method is especially useful for the removal of adherent films (such as those on lenses), and of loose particles from small parts normally inaccessible to a brush or cloth.

The Physics Department of the Royal Cancer Hospital in London demonstrated yet another possibility—the use of a very high ultrasonic frequency (of the order of a megacycle) for 'echo-sounding' the brain. This way it should prove effective in practice to detect such a thing as a brain tumour without any exploratory surgery or probing whatever.

There are continuing developments in 'transducers', that is the crystals or ceramics that transform electrical oscillations into mechanical vibrations, the usual means of producing low-power ultrasonic vibrations. There are similar developments with semi-conductors of many sorts, which in the case of germanium can even produce a triode-like effect and so be used for oscillation and amplification.

The educational value of the Physical Society Exhibition is always considerable, as has often been stressed here. This year it was good to see the parties of senior pupils visiting it. For such students the Colour Group exhibit proved especially attractive. This was devoted to "The Uses of Colour". Colour as a discriminatory aid is familiar to everyone. What many people do not know is that such discrimination has been given practical form in many realms of science and technology—the cooling of electronic components, of medical gas cylinders, signal lights, pipes and conduits in factories, and so on. The use of colour in analysis by spectroscopy—the flame photometer used so much for the determination of sodium in soil and potassium in blood is one modern development—and by chromatography were demonstrated, as well as colour-matching in analysis and diagnosis, attractively shown in the exhibit arranged by Tintometer Ltd.

A special welcome was due to Professor Felici of the University of Grenoble, who made a most interesting contribution to the exhibition. He has devoted many years to one particular problem: the generation of very high direct voltage by electrostatic methods—so to speak the 20th-century version of the never-to-be-forgotten Wimshursts of our schooldays. He has now achieved success, so that potentials approaching half a million volts can now be produced continuously from generators activated by an ordinary mains electric supply. Such generators giving a clean ripple-free high voltage will no doubt soon find uses. (Readers will find pictures of two of Prof. Felici's electrostatic machines in the article entitled "Electrostatic Developments" which J. H. M. Sykes contributed to DISCOVERY, October 1953, pp. 321–4.)

COLOUR BREAKS IN FLOWERS

by

KENNETH M. SMITH, F.R.S.

FIG. 1. Colour breaks in a self-coloured tulip; the flower on the extreme left is uninfected by virus.

Since this article is concerned with a special effect of viruses upon plants, it is perhaps advisable to state briefly what we mean by a virus. These agents, which attack all kinds of living organisms, are much in the news by reason of their great importance to man and his economy. They are extremely small (few of them reach sufficient size to be seen with the optical microscope), and they differ from most visible disease agents, such as bacteria and fungi, in that they cannot be propagated outside a living cell. Another peculiarity is their relationship with insects, on which many viruses, particularly those affecting plants, depend for their transport to new hosts.

The symptoms of virus diseases in plants are extremely varied, and virus infection can give rise to stunting, distortion, leaf mottling and abnormal growths. In addition to these effects, there is another reaction in which the colour of the flower is changed by the action of the virus.

So long ago as 1576 one, Charles l'Ecluse, published a description of a peculiar variegation in tulip flowers. Some years later, in 1662 to be precise, illustrations of similar variegated tulips were figured in *Theatrum florae*, and these have been identified as the work of the painter Daniel Rabel. Those are the earliest records known of the condition now called 'tulip break', which is due to infection with a virus transmitted by aphids. At one time these 'broken' tulips were prized as a rarity and some fetched quite high prices. Not many years ago, the writer noticed in a shop in Istanbul that a number of these diseased tulips with their colour 'break' had been bunched separately and were being sold at a higher price than the self-coloured healthy tulips. 'Broken' tulips are not fashionable in Britain nowadays, but you will still see them being sold by the flower-sellers of Paris, for example. Actually the 'break' in the colour can be quite attractive and the 'pencilling' of the petals is sometimes extremely pretty (Fig. 1). The colour break due to virus occurs in many other flowering plants.

There are at least three types of colour breaks found in tulips and each is due to a different virus. The best known is that shown in Fig. 1, and is the type illustrated in paintings of the time of Rembrandt. This kind of break is caused by the virus now known as *tulip mosaic virus*, and it takes the form of featherings about the margins of the petals, or of fine stripes or streaks up the middle of each flower segment, the stripes being separated by patches of clear ground colour, usually white or yellow. In addition to these symptoms shown by the flowers, some varieties of tulips show a striping or mottling of the *leaves*. On the whole, tulip plants infected with tulip mosaic are smaller and less thrifty than healthy tulips.

There is another virus which, by reason of its ability to infect a great number of flowering plants, is of considerable importance to the horticulturist. This is the virus of *cucumber mosaic*, which frequently infects tulips. We shall meet this virus again in discussing other plants. Like the tulip mosaic virus, it is aphid-transmitted, and so has no difficulty in being carried around from plant to plant. In tulips the 'break' caused by cucumber mosaic is duller and less attractive than that due to tulip mosaic virus; the margins of the stripes are less sharply defined, and the outer petals show a grey or greenish blemish.

We now come to an interesting group of very similar viruses which have a rather curious history. They were first discovered, a good many years ago, quite by chance in the roots of apparently normal tobacco plants growing in the insect-proof glasshouses at Cambridge. At that time there was thought to be only a single virus, but some years later it was shown by two workers, F. C. Bawden and N. W. Pirie, that there exists a group of viruses, all of which are biologically similar but serologically distinct. The interesting points about these viruses are, firstly, that they cause no disease in the affected tobacco plants; and secondly, that they have no insect vector, but are spread about in contaminated soil. Now, although these viruses appeared to cause no disease in the tobacco plants under natural conditions, they would do so if they were extracted from the roots and then rubbed on the leaves. Under those circumstances they were found to produce a local disease in the leaves known as *necrosis*; hence the viruses were given the name of 'tobacco necrosis'. The tulip next came into the story when Kassanis, a research worker at Rothamsted Experimental Station, isolated a tobacco necrosis virus from some badly diseased tulips. Here one meets an important

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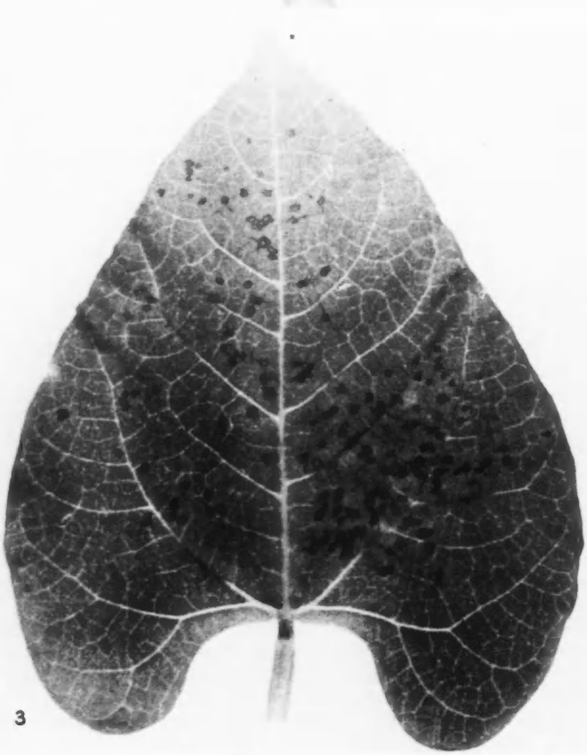

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FIG. 2. Streaking of tulip petals by tobacco necrsis virus.
a French bean inoculated with virus from one ofhe petals
break in honesty, caused by the cabbage black ingspot v
flower. FIG. 6. White break in yellow flowers o Chinese
virus. FIG. 7. Viola infected with cucumber mosc virus; t
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by tobacco necrais virus. FIG. 3. Necrotic lesions which developed in virus from one ofhe petals of the tulip shown in Fig. 2. FIG. 4. Colour e cabbage black ingspot virus. FIG. 5. White break in a red anemone yellow flowers o Chinese cabbage caused by the turnip yellow mosaic th cucumber mosic virus; the picture shows the streaking of the flower.
(All the otographs illustrating this article were taken by S. Frey)

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FIG. 8. White break in a dark coloured stock caused by cabbage black ringspot virus.

point of difference between the behaviour of this virus in the tobacco plant and its behaviour in the tulip. In the former it is apparently unable to move out of the roots (which it enters from the soil), and so it cannot produce a 'systemic' disease affecting the whole plant; in the tulip it can move up into the plant and the resulting disease is extremely severe. Sometimes the tulip is so badly distorted and crippled that no flowers are produced; on other occasions the flower may show some rather peculiar lines or striations on the petals (see Fig. 2). The leaves of tulips infected with this virus are always more badly affected than the leaves of tulips with mosaic.

Now in the case of a tulip infected with a tobacco necrosis virus, we can test fairly easily for the presence of this virus by means of what is called an 'indicator' plant. This is a plant which responds rapidly and in a characteristic manner to a particular virus. In our particular case the plant used is the French bean (*Phaseolus vulgaris*), and its reaction can be seen in Fig. 3. In a typical test one of the petals of the tulip shown in Fig. 2 was detached and ground up in a mortar. The resulting juice was lightly rubbed on the leaf of a French bean, and in a very short time—about 48 hours—the necrotic lesions, characteristic of the virus, developed as shown in Fig. 3.

Another colour break which is almost as well known as the tulip break occurs in the wallflower, especially the blood-red variety. The break consists of a yellow fleck or streak, which varies considerably in size and extent. As a rule the leaves of affected wallflowers show a slight dark green mottling. The virus causing this break comes from broccoli and cabbage plants, in which it causes a severe disease known as *cabbage black ringspot*. This virus, together with cauliflower mosaic virus, causes serious losses to farmers who grow cabbages and broccoli, especially in the south-west of Britain.

Several decorative Crucifers in addition to the wallflower develop a similar colour break when infected with this virus. In Fig. 4 is seen a piece of honesty in which the flowers show the characteristic flecking. A similar effect occurs in stocks (Fig. 8), sweet rocket and rock cress (*Arabis*).

Not long ago a new virus was identified which attacks turnips, broccoli, kale and other cruciferous crops. It was called *turnip yellow mosaic*, because of the extremely bright yellow mottling it caused on the leaves of Crucifers, especially the leaves of turnips. This virus is interesting in several ways, one of which is the fact that it is transmitted by the turnip flea beetle instead of by the more usual sap-sucking insects. It causes a white 'break' in the cruciferous crops with yellow flowers; Fig. 6 illustrates the break in the flowers of a Chinese cabbage infected with this virus. Incidentally, the turnip yellow mosaic virus is becoming of importance to growers of broccoli in the Newcastle area, and it may be expected to spread wherever the turnip flea beetle is abundant.

Earlier it was mentioned that the virus of cucumber mosaic attacks a variety of ornamental plants in many of which it causes a colour break. Among them is the Viola, and in Fig. 7 can be seen a plant infected with this virus; the flower shows a large number of very marked striations which can be seen more plainly on the back of the bloom. The mosaic mottling on the leaves can also be seen in the photograph. The diseased plants are smaller than normal and their flowers are rather inferior.

Another plant which is commonly infected with cucumber mosaic virus is the gladiolus. In the varieties with a pink flower the virus causes a distinctive white streak.

Mention must be made of the anemone. Like all plants which are vegetatively propagated by means of cuttings, runners, corms, bulbs, etc., the anemone is more likely to be virus-infected than happens to a species of plant that is raised from seed. This is because few plant viruses are seed-transmitted, whereas all of them are passed on by the vegetative parts of an infected plant. In the south-west of England anemones are grown on a large scale, and the commercial growers in that part of the country are seriously perturbed at the increasing deterioration of their stocks. In the writer's opinion this deterioration is mainly due to the accumulation of viruses, and this view is supported by the fact that no less than three viruses have been isolated at Cambridge from anemone plants. The three viruses are those of tobacco necrosis (which we have already met in the tulip and which seems increasingly common in many different kinds of ornamental plants), cucumber mosaic and a new virus which may be peculiar to the anemone plant. Fig. 5 shows one of these virus-infected anemone plants; instead of the normal red flower one gets a flower with red and white stripes.

There are plenty of other examples of colour breaks caused in flowers by viruses, but the ones I have cited are commonly met with and are representative of this interesting phenomenon.

THE HISTORY AND GENETICS OF THE RASPBERRY

by

GORDON HASKELL, Ph.D.

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FIG. 1. The 'Rafpis' or Raspberry plant in John Parkinson's *Paradisi in Sole*, published in 1629.

There are many kinds of raspberries, which are so-called from their rough stems. Their centre of origin is believed to be Eastern Asia, and nearly 200 forms have been described for parts of Asia alone. Cytological examination has shown they are diploid (2n 14), and this chromosome number is common to the three species man has domesticated.

The raspberry grows wild in Europe as far north as latitude 70°, and extends south to Asia Minor (40°). In Britain the red European raspberry (*Rubus idaeus*) grows wild, mostly in woods, in all vice-counties except West Cornwall and Pembrokeshire, being more common in northern counties. It thrives where fires have been. In mountainous countries like Switzerland wild raspberries occur in patches both in open valleys and on bare slopes. The remains of raspberry fruits have been found in debris of the Swiss lake dwellings.

Wild raspberries are very variable, especially in cane colour, in shape, colour and number of prickles, and in leaflet shape. They closely resemble cultivated types, differing mainly in being smaller and in having smaller, drier fruits. Cultivated forms often escape and their seeds spread naturally in the wild, birds being the chief disseminating agents. Darwin wrote that yellow-fruited types are not much touched by birds and hence in nature are at a disadvantage to reds; however, wild yellow-fruited types do occur.

Raspberry flowers are normally hermaphrodite (i.e. they have both anthers and styles) and they are pendulous. Their abundant nectar is sought by bees, even after rain when many other flowers are spoiled. The bees collect masses of white pollen from the flowers and they also like the juice of ripe berries. In some countries like Switzerland raspberries are important for honey production.

M. B. Crane has found there is almost no self-pollination. Raspberry flowers are mostly outcrossed and this may be due to protandry (pollen shedding before styles are receptive), as there is no self-incompatibility; or it may be due to pollen competition. Natural hybridisation would also be expected in nature because selection would eliminate self-pollinating types owing to their depression through inbreeding.

EARLY HISTORY

Red raspberry cultivation in England has not a long history (Table 1). The raspberry was first mentioned by Turner in 1548 and then for a hundred years (1629–1729) it seems to have been ignored. By 1826 there were twenty-three sorts, with twenty-five synonyms, yet these were not distinguished generally by gardeners, who gave them little attention. Since then its evolution in England and Scotland has been more rapid. Cultivated types are now mainly subglabrous (i.e. only slightly hairy), although most wild forms are hairy. N. H. Grubb believes that about half the commercial British varieties are chance forms from gardens or from the wild.

Nowadays strawberries and raspberries in England together are the two most important soft fruits cultivated by commercial growers. There are about 4000 acres of raspberries; a quarter of this acreage is in Kent. In Scotland there are some 6000 acres under cultivation, the chief centres being Perth and Angus (see Fig. 2). One reason for successful growth here is the light to medium texture of the soil overlying a porous subsoil; an average crop of not less than one ton per acre is expected in Scotland (cf. Table 2).

The imported European raspberry was cultivated in American gardens prior to 1866, but did not grow too well. It was followed by natural hybrids of European varieties with selections of native American red raspberries (*R. strigosus*), which grew more satisfactorily in gardens. This species is distinguished from the European by its

more slender habit, less erect canes, and narrower and thinner leaves; its fruits vary in size and colour, and were collected by American Indians before the arrival of the white man. Modern American varieties of red raspberries are thus derived from both European and American species. Forms with yellow- and apricot-coloured fruits appear only among the European varieties or American ones that have some European ancestry.

A third cultivated species is the American black-cap (*R. occidentalis*), which is highly variable in the wild. This segregates yellow-fruited forms, which are commonly found wild in N. America. Black raspberries were not cultivated until the first half of the 19th century; the first such variety was *Ohio Everbearing*, which was taken from the wild. Varieties of this species have been improved by selection.

Most wild raspberry species intercross with one another, although the seedlings may be infertile. The black-cap sets fruit and fertile seed with pollen from the European red raspberry; its hybrids, which have intermediate characters and are purple-fruited, can be highly productive and have been cultivated in N. America since 1860.

VIRUS DEGENERATION

Any history of raspberries would be incomplete without a mention of the role of viruses. No cultivated variety is much older than twenty to thirty years, and this is because of the serious degeneration caused by viruses and other pathogens. The National Fruit Trials have repeatedly received for trial new varieties which show promise and appear to be superior even to *Lloyd George*, yet eventually

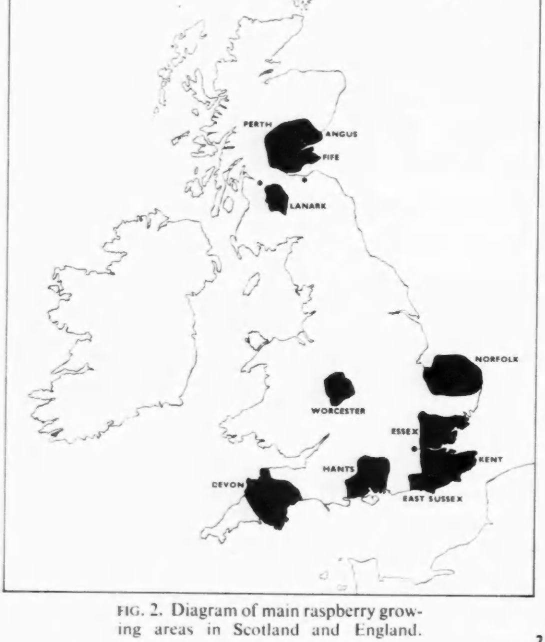

FIG. 2. Diagram of main raspberry growing areas in Scotland and England.

TABLE 1. EARLY HISTORY OF RASPBERRIES IN ENGLAND

Date	*Author*	*Comments*
1548	Turner's Herbal	"They growe in certayne gardines in Englande"
1618	William Lawson	Used as ornamental garden plant
1629	John Parkinson	White and red described, and herbal uses of plant
1729	Batty Langley	Describes white, red and purple raspberries
1757	Thomas Hitt	Four kinds listed: common small red, and white; two other sorts of same colours but much larger fruits
1778	Mawe-Abercrombie	Varieties mentioned are common red, white-fruited, *twicebearing* red and white; smooth-stalked (lacking bristles) also noted for first time
1817	George Brookshaw	Three varieties: red and white Antwerp and the common raspberries
1823	George Brookshaw	Description of wild habitat in England; indication that it was not much cultivated
1826	Horticultural Society, London	23 sorts described

TABLE 2. RASPBERRY YIELDS IN A 4-YEAR TRIAL IN FORFAR, ANGUS

Variety	*4-year total Cwt. per acre*	*Average for 1 year Cwt. per acre*
M. Promise	298	74·5
M. Landmark	276	68·9
M. Jewel	272	68·2
Norfolk Giant	260	64·9
Lloyd George	260	64·5
M. Notable	220	54·9
M. Enterprise	220	54·6
Newburgh	200	49·1

(*Data from C. A. Wood and M. Boase.*)

they undergo deterioration through virus infection. Cadman and Hill established that two aphids (*Amphorophora rubi* and *Aphis idaei*) transmit mosaic diseases in raspberries grown in Britain.

The mosaics are of two types: Mosaic 1 produces plant symptoms such as yellowing of the leaves, and reduction in vigour, whereas Mosaic 2 does not show such readily distinguishable symptoms and can be detected only by grafting on to more sensitive hosts. Carrier varieties eventually show degeneration. Leaf-curl virus severely attacks some varieties in Scotland, and in England stunt virus produces severe dwarfing.

Fig. 3 shows the extent of the degeneration caused by viruses in a *Mitchell's Seedling* crop grown in Angus. Generally there is slow spread of mosaic under field conditions. There is no effective control of the virus vectors, but there are means of obtaining virus-free raspberry stocks. It is important that clones are maintained free from disease, and this is done by growing them where the vectors are absent (e.g. in New Zealand) or by careful

inspection of the fields devoted exclusively to the production of propagating canes, as in Scotland. The virus-free New Zealand strain of *Lloyd George* raspberry has brought new life to this famous variety, but already in some areas it has begun to show signs of degeneration.

GENETICAL CHARACTERS

Domestication of the European raspberry has usually resulted from man selecting recombinations and segregations of quantitative and qualitative characters, and mutations. Polyploidy has played relatively little role in improvement, in contrast to blackberries and raspberry-blackberry hybrids, and many other cultivated plants. Crane, Lawrence and Lewis of John Innes have found that several characters show Mendelian inheritance by single genes, while some (e.g. fruit colour) are controlled by two genes. Mrs. T. Dayton, using paper chromatography, finds that fruit colour is related to the amount of cyanidin present, so that the genes controlling fruit colour act by controlling the production of cyanidin.

Sex is also genetical. Varieties are normally hermaphrodite, but plants with only male, female or neuter flowers occur according to their heredity. The variety called *Superlative* throws plants that are either hermaphrodite, female, male or even neuter; these characteristics are associated with leaf appearance. Plants with male flowers only are similar to a wild type called *obtusifolius* with undivided leaves on its second-year canes. The leaves of neuters are also rounded and distinct from normally lobed and spaced leaves. Varieties like *Lloyd George*, which are homozygous for sex, have flat leaves, while heterozygotes like *Superlative* have somewhat curled foliage.

Many commercially valuable characters (i.e. plant vigour, spine intensity, fruit shape, size, firmness, time and ease of picking) are biometrically inherited. Even a highly variable character like fruit flavour is inherited, although selection for improved flavour depends on whether the breeder is himself genetically determined for tasting ability. It was once thought that fruit size is inversely proportional to flavour; my recent work shows this is not so and large fruits of good dessert qualities may be obtained.

Although raspberry canes are hairy, there is a gene (H) for hairy canes associated or closely linked with a lethal on the same chromosome. Hence homozygous hairy (HH)

TABLE 3. PEDIGREES AND USES OF MALLING RASPBERRIES

Variety	*Parentage*	*Main Use*
Enterprise	Preussen × (Lloyd George × Pyne's Royal)	Canning; quick-freeze
Exploit	Newburgh × (Lloyd George × Pyne's Royal)	Quick-freeze
Jewel	Preussen × (Lloyd George × Pyne's Royal)	Canning; quick-freeze
Landmark	Preussen × Baumforth's Seedling A	Jam
Notable	Preussen × Lloyd George	Home-made jam
Promise	Newburgh × (Lloyd George × Pyne's Royal)	Jam

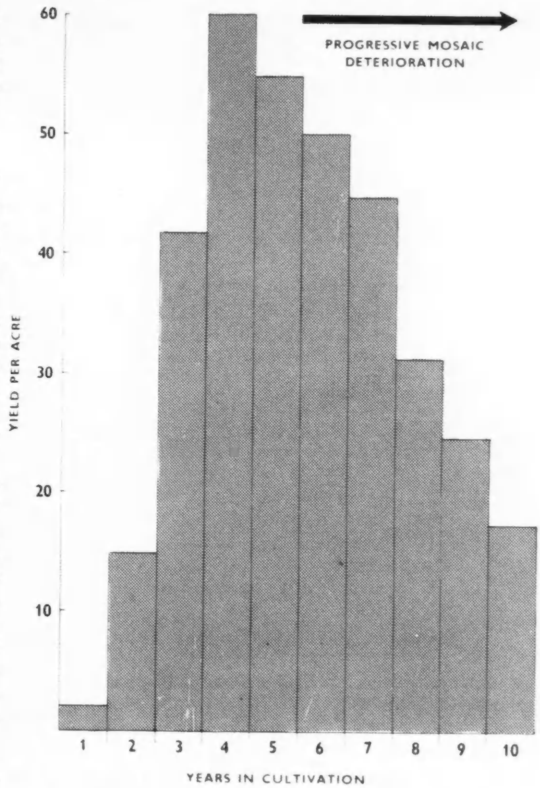

FIG. 3. Degeneration of a plantation of *Mitchell's Seedling* raspberry grown in Angus (data from J. S. Chisholm).

plants do not occur and this may explain why there are wild subglabrous plants. Many varieties like *Lloyd George* are heterozygous for yellow fruits, which appear in their progeny. Yellow- and apricot-coloured fruits may taste as nice as reds but are unpopular, just as red tomatoes and strawberries are preferred to yellow or white types.

OLD AND NEW VARIETIES

Of the older varieties, *Red Antwerp* was considered good in Europe and N. America, and *Semper Fidelis* was favoured for jam making; both have been ruined by mosaic degeneration. *Pyne's Imperial* and *Pyne's Royal*, now replaced, are said to have had the largest fruits. It is clear from the pedigrees (see Table 3) of some of the varieties which N. H. Grubb raised at the East Malling Research Station, that new varieties have limited parentage and are descended from these older varieties. *Lloyd George*, *Preussen* and *Pyne's Royal* have been most important parents. *Lloyd George* was found growing wild in a wood near Corfe Castle in Dorset and was introduced into commercial cultivation about 1920, while *Preussen* was a German variety that was introduced in the nineteen-twenties. *Pyne's Royal* was introduced by T. B. Pyne, of Topsham, Devon, in 1913.

The most important red varieties to come from American research stations have been *Latham*, *Washington Willamette* and *Taylor*; *Bristol Black* is the only black variety. *Washington* and *Willamette* were especially bred for autumn hardiness in Oregon and Washington States; their buds remain dormant in autumn, whereas other varieties (e.g. *Cuthbert*) start to grow again and so are killed by autumn frosts. *Latham* was introduced in 1912, being now the only variety produced before 1930. It resulted from a breeding programme to obtain an early hardy variety in Minnesota. Most new American varieties have come from this source.

The two leading Canadian varieties are *Viking* and *Latham*. The latter is hardy, and both are suited to colder regions. There were eleven introduced varieties of red raspberries in Canada between 1920 and 1950. *Lloyd George*, *Newman* and five other varieties have been the most important parents of these. In the United States in the same period 26 varieties were introduced commercially. Four varieties (viz. *Lloyd George*, *Cuthbert*, *Newman* and *Latham*) went into their ancestry, but fourteen other parents were also involved. *Cuthbert* was found as a chance seedling near New York City in about 1865 and *Newman*, of unknown parentage, was introduced in Quebec in 1918. Eight black, six purple, one yellow and one amber variety have also been introduced in the United States.

BREEDING NEW RASPBERRIES

Ideal raspberries of the future would have the characters indicated in Table 4. A prerequisite for the success of any new introduction having all these ideal characters would of course also apply, namely that healthy vegetatively reproduced stocks must be available. In Scotland the factors of frost-resistance, dessert versus jam quality, quick-freezing properties and whether the fruits darken are most important. In N. America cold-tolerance and resistance to mosaic are important.

Raspberries vary considerably in spine density and in spine size, and possibly both these will be further reduced by selection. It was for this reason that Prof. Yeager, in New Hampshire, crossed a cultivated red raspberry with the flowering raspberry, *R. odoratus*, but unfortunately all hybrids proved weak and sterile.

N. H. Grubb (1937) has summarised his breeding studies at East Malling Research Station. He found that self-pollination of varieties like *Norwich Wonder A* produced some seedlings which were superior to the parent; though it is generally difficult to get a better seedling if the parent is already good. On the whole he rejected the general use of selfed selections, as he found no correlation between a variety's commercial value and the proportion of worth-while selfed seedlings. Varieties that produced the best selfed seedlings always gave equally promising results when crossed. However, other workers have thought a more hopeful approach is to cross different selected seedlings from selfed families. Since 1922, when Mr. Grubb first described the varieties then in commercial cultivation, all except *Lloyd George* (which, in 1922, had only just been introduced) have gone out of favour. All the other varieties he listed are now extinct, or rapidly becoming so, and this has happened largely because of virus degeneration.

TABLE 4. SPECIFICATION FOR A HYPOTHETICALLY PERFECT RASPBERRY PLANT

Ideal Plant Characters	*Ideal Fruit Characters*
Produces enough canes but not smothering fruits (i.e. compact)	Large and firm
Vigorous growth	Smooth outline, compact, not crumbly
Erect habit	Easy to pick and plug
Smooth canes lacking spines	Colour bright red, not later turning dark
Resistant to diseases and pests	High dessert quality
Hardy to frosts	* * *
Heavy and consistent cropper	*For jam making* a soft fruit is desirable
Adaptable to different soils and climates	
Requires little fertiliser	
Strongly attached fruiting laterals	

As raspberry seeds do not transmit viruses, M. B. Crane and Dr. D. Lewis, of John Innes, tried using propagation by seed to overcome degeneration. Five hybrids were found to give high yields, but their fruits were too variable in colour and firmness to warrant commercial use. Slight variation is not undesirable as it acts as a buffer, for a whole crop of similar plants may fail because of epidemic disease or because all the plants react badly to deleterious climatic influences. Crane and Lewis found that during the first two years new hybrids outyield clones, but they become infected with virus and show depression by the third year. Some well-known varieties (e.g. *Norfolk Giant*) hold out against virus depression, and others like *Lloyd George* give a fair crop in spite of ravages by virus. It seems also that most cultivated varieties have already been selected for hybrid vigour.

Inbreeding and hybridisation to produce vigorous F_1 hybrids was not undertaken in America as it was considered better to continue with varietal crosses. However, C. F. Williams in N. Carolina has crossed American red and black raspberries with foreign species adaptable to the climate of the south-eastern States. The F_1 hybrids were then continually backcrossed to the American parents. Two varieties—*Dixie* (involving *R. biflorus*) and *Mandarin* (involving *R. parvifolius*)—have been introduced. According to Dr. G. M. Darrow, desirable characters thus obtainable are resistance to disease, heat and drought, small seeds, early to late ripening, firm and large fruits, great vigour and productivity.

The use of purple raspberries in Britain has not been fully explored, although Mr. Grubb has been investigating their possibilities. It might be possible to combine desirable properties of both reds and blacks into one superior type by back-crossing and segregating the hybrids.

Apomixis (non-sexual seed formation) is absent in raspberries, although common in blackberry and some blackberry-raspberry hybrids. Only one variety, *Taylor*, has shown signs of possible apomixis, according to which

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FIG. 4. Fruiting branch of the black raspberry (*R. occidentalis*), a native species of North and South America. Other species of black raspberries occur in Asia. (*Photo by G. M. Darrow*)

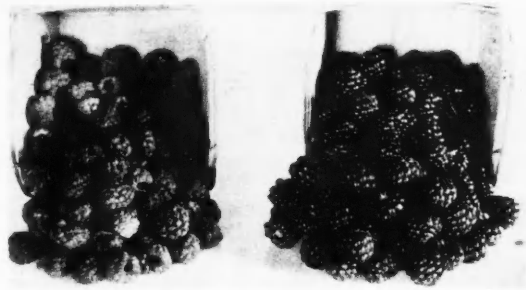

FIG. 5 (*left*). Fruits of an American red raspberry (*R. strigosus*). (*Right*) A trailing red raspberry (*R. parvifolius*) with glossy fruits. Hybrids between these types are adaptable to conditions in southern states of the U.S.A. (*Photo by C. F. Williams and G. M. Darrow*)

FIG. 6. Fruiting branch and fruits of a healthy plant of *Lloyd George*, one of the most popular of all raspberries. (*Photo by East Malling Research Station*)

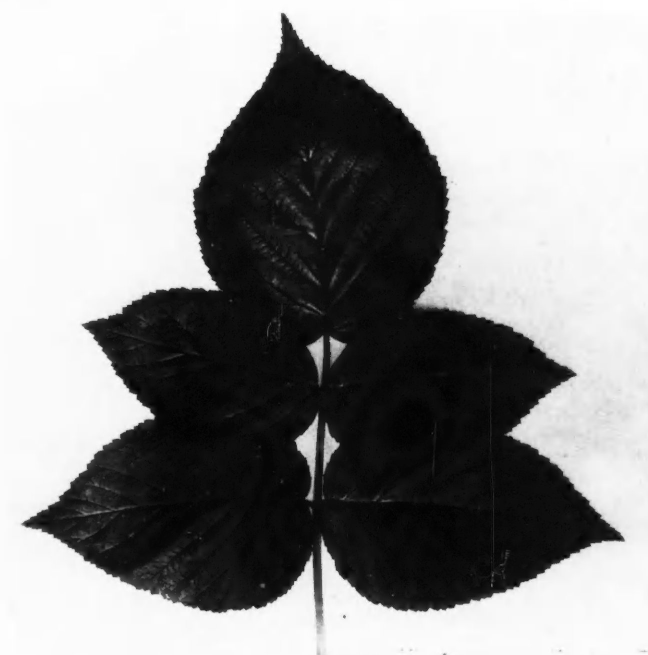

FIG. 7 (*above*). Symptoms of group 1 virus infection on leaf of *Norfolk Giant* raspberry. Note the chlorosis along the veins. FIG. 8 (*right*). A virus-free leaf from the stem of a healthy plant of *Lloyd George* variety.

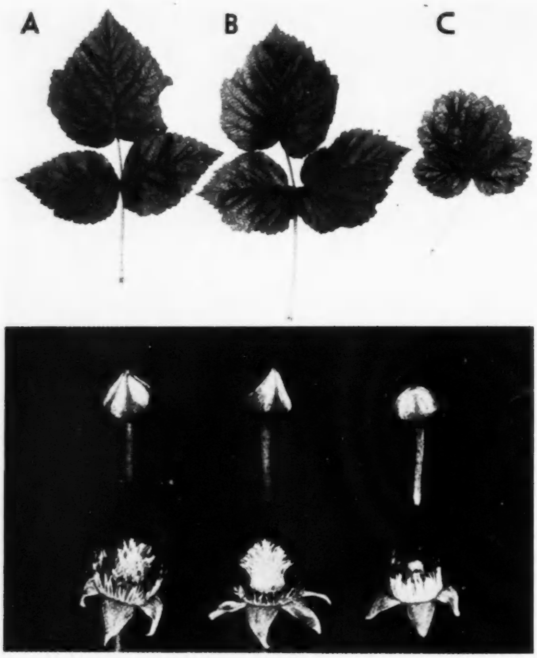

FIG. 9. Flowers, flower buds and leaves of hermaphrodite (A), female (B), male (C) raspberry plants. The tri-foliate leaves are from flowering canes, i.e. two-year-old growth. (*Photo by M. B. Crane and W. J. C. Lawrence.*)

pollen parent is used. Indeed, one commercial red variety in New Hampshire, called *Durham*, is said to result from pollinating *Taylor* with the Nectarberry (a large-fruited blackberry from California).

POLYPLOIDY AND AUTUMN FRUITING

Most varieties flower in the spring and fruit in summer on second-year canes; these are summer-fruiting varieties. Some bear flowers at the end of first-year canes and produce ripe fruit in October; these are autumn-fruiting varieties. Some types are both summer- and autumn-fruiting; thus *Lloyd George* is summer-fruiting, but when this variety is thriving it produces terminal flowers and fruits on young canes late in autumn. This diploid variety has characteristics not unlike autumn-fruiting varieties, which are often tetraploids. Large flowers, abundant canes which require thinning, large leaves with an under-surface that is white rather than grey (due to a more dense covering of hairs) are characteristics of tetraploids. These are not immediate tetraploid characters, but those tetraploids which have them have survived.

November Abundance is triploid ($2n = 21$), whereas *Everbearing* and *Hailshamberry* are tetraploids ($2n = 28$). The origin of polyploid autumn-fruiting raspberries is probably by autoploidy, i.e. from simple duplication of the diploid chromosome complement. M. B. Crane has pointed out that different individuals are often found with one name in autumn-fruiting types, and some varieties now triploid were originally tetraploid. They have hybridised naturally with diploids, and the hybrid triploid seed has germinated alongside the tetraploid parent and has eventually been selected. Indeed, at least one named variety of raspberry is triploid or tetraploid, depending on the source from which one obtained specimens of it. Possibly the triploids are rather sterile and are vegetatively more vigorous; this consideration may account for *Hailshamberry* stocks going sterile.

Characters like increased size and hairiness result directly from increase in chromosome number, but this does not produce autumn-fruiting. Late fruiting occurs in diploids, but spontaneous triploids do not necessarily have the autumnal habit, although possessing certain other polyploid characteristics. This habit is therefore held to be due to a recessive gene. Why, then, is autumn-fruiting rare among diploids but common to polyploids? Dr. Lewis has found that summer flowers of tetraploid varieties have practically no good pollen; hence in nature they cross-pollinate only with pollen from diploids. This leads to more or less sterile triploid offspring. On the other hand, autumn flowers have abundant pollen and therefore mainly cross-pollinate with other tetraploids. There has thus been rigorous natural selection favouring tetraploids with autumnal fruiting. A gene somewhat disadvantageous at the diploid level produces higher survival in tetraploids.

Dr. Lewis has also found that when self-pollinated, tetraploids such as *Everbearing* throw only 25% true tetraploid offspring, while the remainder have one less or one, two or three more chromosomes than the true tetraploid value. These are indistinguishable from normal. This is unusual, as in other species addition or loss of a chromosome may markedly affect morphology. Triploids occur among the progeny of diploids in a ratio of about 1 in 400; when selfed they produce many tetraploids, which in fertility and morphology resemble established tetraploid varieties. This supports the view that cultivated tetraploid raspberries arise either in *one* or *two* steps, involving unreduced gametes from the diploids.

Polyploidy and apomixis have been relatively insignificant in the domestication of raspberries, though they play an important role in blackberry evolution. Prof. P. T. Thomas of Aberystwyth has suggested that raspberry and blackberry chromosomes have become differentiated not so much by structural changes, but more by genic differences controlling physiological processes such as chromosome pairing. This is perhaps related to their differences in behaviour.

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THE REMARKABLE "PLATINUM AGE" IN SPAIN

In Britain the name of W. H. Wollaston (1766–1828) is particularly associated with platinum because of the famous process for rendering the metal malleable which he perfected about 1805, though he did not disclose the secrets of his technique until he was dying—his classic paper "On a method of rendering Platina malleable" was written while he lay on his deathbed. But scientific interest in platinum pre-dates Wollaston's work by a number of years. The first platinum was brought to Europe from South America by Spanish adventurers, hence the name platinum, which was derived from 'platina', diminutive of the Spanish word for silver. This article describes the early scientific work on this metal which was done in Spain some time before Wollaston produced malleable platinum.

The recent Platinum Metals exhibition sponsored by the Institution of Metallurgists* reminded us of Wollaston's discovery of the process for rendering platinum malleable, but it is important to realise that substantial success had been achieved by an earlier scientific worker, a contemporary of Proust who worked in Spain.

Wollaston's process had a true scientific basis since it demonstrated the necessary separation of other metals of the platinum group, which are always present in crude platinum and cause embrittlement. Yet before Wollaston fathered powder metallurgy by perfecting his method for the conversion of platinum grains into malleable sheet suitable for making crucibles, dishes and huge evaporating-basins (in which he was able to concentrate sulphuric acid), leading scientists in Europe had been using platinum crucibles and equipment in their laboratories.

What was the origin of the platinum apparatus used by Guyton Morveau and the platinum crucibles that belonged to Sir Joseph Banks, president of the Royal Society? The answer is that this malleable platinum came from Spain, where it was produced in Madrid in considerable quantities by Pierre François Chabaneau, colleague of Joseph Louis Proust, another Frenchman who was attracted to Spain whose capital possessed the most magnificent chemical laboratory then in existence. Both Chabaneau and Proust were born just 200 years ago, and their bicentenary provides an opportunity to commemorate the remarkable work they did in Spain. Chabaneau's name has almost been forgotten, but Proust remains well known as the discoverer of the Law of Definite Proportions. It was the same Proust who—as "Don Luis" Proust—was granted in 1799 no less than *46 kilograms of crude platinum and 18½ kilograms of purified platinum.* All this metal was delivered to Proust in his Madrid laboratory, which thus came to possess a quantity of platinum probably exceeding the total amount belonging to all the other laboratories in the world! That quantity of platinum would, of course, be worth a small fortune today, for the present price of the metal is about £30 per ounce. One thus gets some idea of the lavish scale of the patronage of Charles III of Spain. (It is reminiscent of Napoleon III's championing of Deville's pioneer work on the production of aluminium, though the cash value of Proust's platinum far exceeded the amount of money which Napoleon III made available to Deville whose exhibit of aluminium extracted from clay drew so much attention at the Paris Exhibition of 1855.)

* An article about Wollaston was published in DISCOVERY, Nov. 1953, pp. 342–4.

Both Proust and Chabaneau had held poorly-paid posts in their native France before they were persuaded to take up academic posts in Spain. Proust had learnt some chemistry while serving in his father's apothecary's shop at Angers, after which he studied in Paris under that eccentric man of science, Guillaume François Rouelle (1703–70). Although it provides entertaining reading to follow Rouelle's fantastic methods at the Jardin du Roi in Paris, to hear of him having his wig blown off when an experiment ended in an explosion, and to learn how he could continue with his lecturing while ransacking a storeroom to find some evasive piece of apparatus so that his students found their notes losing continuity to say the least—all this is of less import than one vital point. That is that it was Rouelle who inspired both Lavoisier and Proust to take up chemistry—a fact sufficient in itself to win immortality for him. Rouelle's lectures were as famous and significant in their time as, say, those of Davy at the Royal Institution; as one writer puts it, "All the world flocked to the chemistry course of Rouelle, the widely distributed prospectus for which made a special feature of the interesting experiments it included."

Among the substances discovered by Proust was glucose—grape sugar as it was called then—and he followed this up by work on the higher sugars. For a time he taught at the Artillery Academy at Segovia, but his most important period as a teacher must have been when he was on the staff of the great Seminary of Vergara, where the professors included Chabaneau and the two De Elhuyar brothers (whose remarkable analysis of Wolframite ore resulted in the isolation of tungsten).

Then Proust proceeded to his highest post, the directorship of the Royal Laboratory in Madrid. There it was that his story becomes something far more impressive than that of a prosaic chemist teaching young students who were plodding their way towards a general certificate of education, and he developed into something more than just the discoverer of a chemical law, important though that contribution was. Proust, the one-time pharmacist from the Saltpêtrière in Paris, had charge of a laboratory where dishes and even beakers could be made of platinum. This was a period in which Spain suddenly found that her South American platinum, hitherto condemned as an 'impurity' which could cause the abandonment of gold-mines, had become an asset. In spite of all, however, Proust was later to suffer adversity; he was ruined by the Peninsular War, and had to return to France in 1806, where he was granted a well-deserved pension by Louis XVIII.

A range of modern platinum apparatus used for chemical and electro-chemical analysis.

The entry of Chabaneau into the story of Spanish platinum is even more interesting, for his efforts to produce malleable platinum proved remarkably successful, especially in view of the fact that it was later to be discovered that other platinum metals present as 'impurities' can cause serious embrittlement. Chabaneau started his career as a theological student, and there was no science in his curriculum. He took on his first teaching post rather like Bishop Watson who took up the chemistry professorship at Cambridge though he had never seen an experiment or mastered a chemistry book. Chabaneau solved the problem of teaching mathematics at Passy by staying up every night, arduously preparing his notes for the next day's class. From mathematics he turned to physics, and thence to chemistry—hence the transformation of a divinity student into the man who was to revolutionise the utilisation of Spain's platinum resources. He was invited to Vergara to teach physics, and from there the story moves to Madrid where Charles III created for Chabaneau a public chair of mineralogy and chemistry, lodged him in one of his palaces, and granted him not only a surprisingly high salary, but also a valuable library—and the finest chemical laboratory the world had yet seen.

What is remarkable about Chabaneau's production of malleable platinum is the way in which he succeeded, perhaps partly by guesswork, in fulfilling the two essentials for producing the workable metal. First, the platinum must be separated from the other precious metals—rhodium, palladium, osmium, iridium and ruthenium, which accompany it and prevent the successful working into sheet metal. Secondly, the so-called 'sponge' of pure platinum must be compressed into a malleable ingot while still at a high temperature. Chabaneau succeeded on both counts, in spite of the fact that at the time he was developing malleable platinum none of the other platinum metals was known (they were not to be discovered until the days of Wollaston and Smithson Tennant); it has to be realised, moreover, that chemistry was then only just beginning to emerge as a science. Chabaneau had to prepare all the reagents he required with his own hands, and he also had to make all his own apparatus. The samples of platinum he handled varied as regards inclusions of other metals, so naturally he obtained variable results: sometimes the product proved to be malleable, but on other occasions it was disappointingly brittle. "Away with it all. I'll smash the whole business. You'll never again get me to touch the damned metal!"—that was his cry on one occasion when his patron, the Marquess of Aranda, arrived at the laboratory to find Chabaneau hurling out of the window his dishfuls of platinum residues. Contrast this with the vision of Chabaneau achieving success under the eyes of the Spanish king who used to spend long periods in the laboratory watching his favourite scientist at work.

There is, too, the anecdote about the Marquess of Aranda visiting the laboratory and attempting to pick a ten-centimetre cube of solid malleable platinum—an ingot which weighed 23 kilograms: "You are joking; you have fastened it down!" was the comment. But there it was, the most remarkable lump of platinum ever made, an ingot which Chabaneau had produced by compressing and hammering while hot a mass of the metal which he had freed from its 'impurities' in an empirical but satisfactory manner.

Chabaneau's platinum went into many objects, one of them being a magnificent communion cup for the Royal Palace Chapel. He took some of his ingots to Jeanety of Paris, a goldsmith who was without equal when it came to the fashioning of platinum watch-chains and snuff-boxes, and blowpipes and platinum crucibles for the scientists of Europe. Later, like Proust, Chabaneau returned to his native land, to the Périgueux from whence he came.

Proust and Chabaneau were the central figures in this remarkable history of Spanish platinum. That history had begun when Don Antonio de Ulloa, member of a Spanish expedition to South America, had reported how native Indians fished out water-worn nuggets and grains of platinum from the River Pinto. Luckily for De Ulloa when his ship was captured by the British Navy, his scientific manuscripts were returned to him "with pleasure", as our Admiralty put it, "for we are not at war with the arts and sciences nor with their professors". In the Spanish period there was a succession of French chemists who worked on platinum. Another outstanding man who should be remembered along with Chabaneau was Boussingault. It was while Boussingault was in charge of the metal mines of Colombia that the Congressmen of that country decided that they would like to see erected at Bogota a full-size equestrian statue of Bolivar—to be made in malleable platinum! To spare the embarrassment of the over-optimistic politicians he had to withhold his report to the effect that there was insufficient platinum in all the mines to carry out the project, even if it were possible from the metallurgical aspect.

M. SCHOFIELD

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THE A-BOMB'S EFFECT ON AEROPLANE DESIGN

By Our Air Correspondent

FIG. 1. The Vickers Valiant, first of the A-bombers to reach the R.A.F.

It was only to be expected that in the debate in the House of Commons on the Air Estimates there should be talk of atom bombs and the new 'V' bombers.

The surprise came from the Navy. Talking of the Navy Estimates, the First Lord of the Admiralty, Mr. J. P. L. Thomas, made a nine-word statement of great significance. It received very little publicity.

Mr. Thomas was talking of the Royal Navy's aircraft plans. And in a few sentences which barely covered a paragraph of Hansard he referred to the progress being made in the production of a new swept-wing fighter. He said it was too early yet to say when it would be in service, adding: "It will be an aircraft of exceptional performance. It will be equipped with an air-to-air guided missile for air combat, *and it can carry an atom bomb if required.*"

It is hardly likely that any new fighter will be otherwise than supersonic, and if it is contemplated as an attack bomber as well, it will doubtless have considerable range. So the Navy can look forward to a carrier-borne faster-than-sound, long-range aeroplane capable of delivering an atom bomb against an enemy fleet or shore targets.

Probably this aircraft is a development of the Vickers-Supermarine 508, which has already carried out deck-landing trials. This was a straight-wing experimental aircraft with a 'butterfly' tail, and fitted with two Rolls-Royce Avon turbo-jet engines.

But more significant than the Navy's future plans is the supposition to be made from Mr. Thomas's disclosure. And that is, that if an atom bomb can be carried by a ship-borne twin-engined fighter, there should be no difficulty about lifting it in a Canberra bomber. And Bomber Command, Royal Air Force, is equipped wholly with Canberras.

The Canberra, of course, does not have the range of the 'V' bombers which, later on, will equip the Bomber Command squadrons. But Canberras have flown across the Atlantic and in the England–New Zealand air race, last October, Canberras flew very long 'stages'. How far that range is reduced when a bomb-load is carried is one of the operational details which are still secret.

The 'V' bombers, so called from their names, Valiant, Vulcan and Victor, are now in sight. The Under-Secretary of State for Air told the House of Commons recently that the new bombers would be two-and-a-half to three times more effective than their 1945 counterparts in altitude, speed and range. This is a clear indication that they will reach near-sonic speeds at great heights—50,000 or 60,000 feet. In other words they should fly at over 600 m.p.h.

It is significant, perhaps, that the Avro Vulcan is to have Bristol Olympus engines, and a test Canberra fitted with two of these holds the world's aeroplane height record at 63,668 feet.

First of the trio to reach the Royal Air Force will be the Vickers-Armstrong Valiant. Designed by Mr. George Edwards, the Valiant is a four Rolls-Royce-Avon-engined bomber, and first flew on May 18, 1951. Unfortunately the first prototype was wrecked, and the test flight programme was delayed for nearly a year until the second prototype was ready. Now, after two years of intensive tests, operational models are leaving the production line.

The Valiant's wings have a considerable sweep-back on their leading edges, but the trailing edges are only just off being at right angles to the fuselage. The Vulcan is the futuristic-looking delta-winged aeroplane, while the Victor, product of the Handley Page works, has the wing shape known as 'crescent'. The leading edge has three different angles of sweep-back.

It is in the wing designs that the British approach to the problems of the fast, high-flying bomber differs fundamentally from the American.

The United States Air Force have a powerful fleet of Boeing B.47 Stratojets, six-engined aeroplanes, and plans for a very much larger, eight-engined B.52 Stratofortress. Both these designs embrace rather narrow swept-back wings, giving much greater wing loadings, affecting take-off distances very much, and reducing the margin between cruising speed and stalling speed considerably.

In particular, the B.47 is considered in Britain to be a very tricky aeroplane to fly, especially in landing on its 'bicycle' undercarriage. It also needs very long runways to get airborne. British designers have gone for greater ease of handling. A lightly loaded Valiant has taken off at Weybridge in as little as 600 yards, while, thanks to the unusual wing and flap design, Handley Page's claim that once the Victor's controls are properly set during the final approach to the airfield, the aeroplane can land itself.

The Boeing Stratojet is roughly the same size as the Valiant. It has a wing span of 116 ft. against the Valiant's 114 ft. and is 106 ft. 8 in. from nose to tail compared with

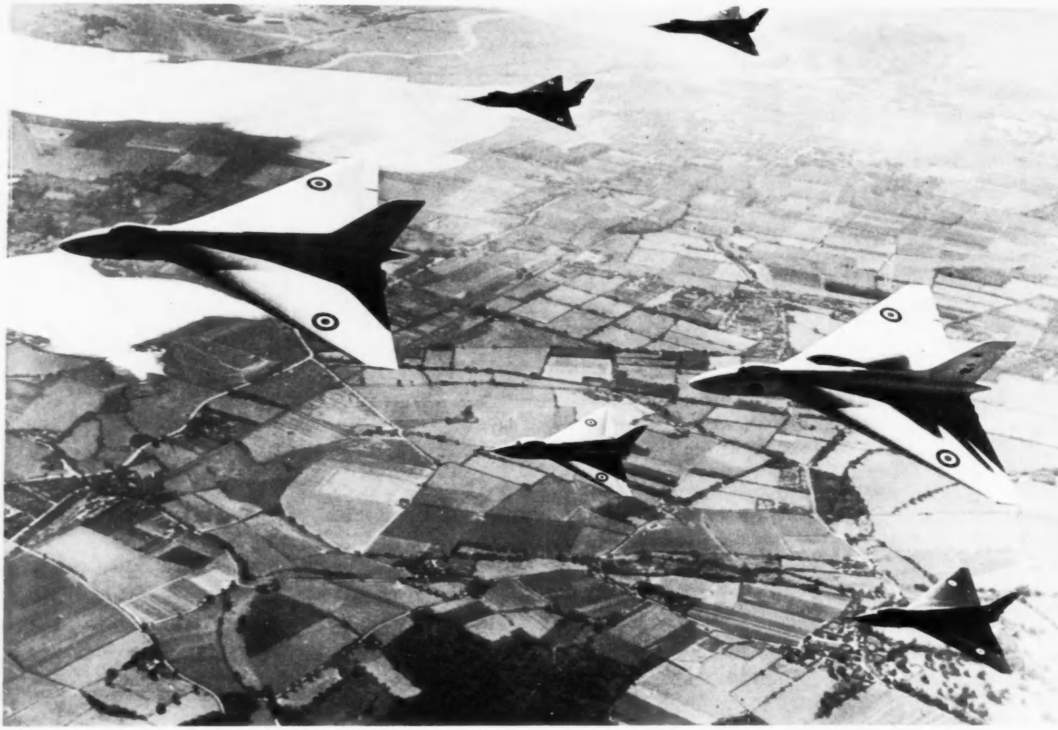


FIG. 2. Second of the trio of 'V' bombers is the Avro Vulcan, an advanced delta-winged aeroplane.

FIG. 3. The trio of 'V' bombers is completed with the Handley Page Victor, with its crescent-shaped wings.

108 ft. 3 in. of the British aeroplane. Though it is a six-jet aircraft, the combined thrust of its six General Electric engines is less than the total thrust of the Valiant's four Rolls-Royce Avons. But the U.S. Air Force has many squadrons of them, whereas the R.A.F. has yet to receive its first Valiant. The Stratojet flies at well over 600 m.p.h., and some units with these aircraft are in England.

The Americans also have a big fleet of several hundred Convair B.36's, giant aeroplanes the size of the ill-fated Brabazon airliner. These have been flying since 1946, and are now obsolescent for all their size. Originally they were designed to have six piston engines with pusher type air-screws, but it was found that they were considerably under-powered and four jet engines were mounted additionally. With this added power, their maximum speed is still less than 450 m.p.h. which, even with the 16 twenty-millimetre cannon they carry, is not sufficient protection against the modern speed-of-sound defensive fighter. The 230-ft. wing span and 62-ft. length of the B.36 provides a big target.

The B.36 was designed to have a maximum range of 10,000 miles, carrying quite a useful bomb load. On short-range operations it can carry 84,000 lb. of bombs. Many of them have been adapted to carry a jet fighter slung in the bomb-bay.

A big all-jet development, with swept-back wings—the B.60—was built and flown, but the U.S. Air Force decided against it, and the orders are for the Boeing B.52.

Both this and the B.47, in true American fashion, have their engines mounted in 'pods' hung from the wings. British designers favour the engines being buried in the wings.

Our Avro Vulcan, designed by Stuart Davies, has been flying since August 1952. It was originally powered by four Avon engines, but the two prototypes now have Armstrong-Siddeley Sapphires in one and Bristol Olympus engines in the other. Production is planned for Olympus engines. The delta-winged bomber is about 100 ft. across at the wing tips and about 90 ft. long.

The Handley Page Victor, the design of Mr. R. S. Stafford, first flew on Christmas Eve 1952, and made its first public appearance at last year's R.A.F. Coronation Review. Its proportions are still not for publication. Its engines are four Sapphires.

When Bomber Command is re-equipped with these 'V' bombers, it is not expected that it will have large numbers. Each aeroplane costs about £500,000, and in any case the days of the 1000-bomber attack are over. Relatively few Valiants, Vulcans, or Victors could deliver a much more devastating attack—even with ordinary high-explosive bombs—than the 1000 Lancaster and Halifax raids of the last war.

The Russians are known to have new long-range heavy bombers in squadron service. These are the Ilyushin 38, about the size of the B.52 but powered with four turbo-propeller motors, and the Tupolev 200, believed to be comparable in size with the B.36. This is a six turbo-propeller aeroplane. Reports from America indicate that over 400 of these two types are based in Northern Russia.

PLASTICS IN HORTICULTURE

E. R. WEBBER

New uses for plastic materials are constantly being found, and it was to be expected that they would eventually find their way into the horticultural world. In the United States their use in this sphere is becoming widespread and there are signs that a keen interest in this kind of application has been aroused in Britain.

The particular plastic material which has become popular among horticulturists is polythene. This transparent plastic has many excellent properties: for example, its moisture absorption is virtually nil; it shows a high resistance to attack by chemicals; it is strong and has good lasting properties. In the U.S.A. it is manufactured under licence and marketed under the name of 'Alathon' and 'Polyethylene'.

The best-known horticultural use of polythene is in the practice of air-layering for woody plants. This technique of propagation was known thousands of years ago to the Chinese, but little has been heard of it recently in the Western world.

It consists of making a cut on the stem of a plant and wrapping moist moss or soil round the cut in order to induce roots to form. The difficulty has been to keep the wrapping material moist. Paper, cloth and rubber wrappings have been tried, but none has proved very successful with the result that when the technique has been used in warm glasshouses it has been necessary to water several times a day to get successful results.

In 1947, Colonel Grove in Florida found that the new polythene film was ideal for keeping the moisture in. In 1950 this idea was taken up by John Creech of the U.S. Department of Agriculture who successfully propagated rhododendrons by air-layering when he used this plastic film.

The technique was next taken up by the Arnold Arboretum in Massachusetts, which has published an account of the procedure which was found effective. This starts with the making of a 2-in. cut upwards on the young twig, alternatively, a complete ring of bark half an inch wide can be removed. The cut surfaces are treated with one of the hormone preparations which promote root growth. Moist sphagnum moss is then packed between the cut surfaces and all round the cut. The polythene film is then wrapped round the moss and fastened with thick adhesive tape. It is essential that no hole be left through which moisture can evaporate.

If properly done, this air layer will remain moist for

several months until rooting takes place. When the roots show through the film, the branch is severed beneath the ball of moss and planted.

Most of the experiments were made with plants which are difficult to root, the purpose being to find out if some of them would respond to the new method of air-layering, which would save the time and trouble of grafting. Most of the layers were put on in either late April or July, and were removed in October. Even with most of the failures the stems were well calloused, and even here good results might be achieved with a little more skill in application of the technique.

In England similar work has been done by the Royal Horticultural Society at Wisley and by Plant Protection at their Fernhurst research station. The Royal Horticultural Society is reported to have had a considerable degree of success during the past two years but, at the moment of writing, it has not published a detailed report of the results. At Fernhurst, polythene film has been used for the aerial-layering of semi-woody, greenhouse plants, but although rooting took place quickly with some of these the experiments were not considered wholly successful.

THE TECHNIQUE FOR CUTTINGS

Following the same principle, plastic film has been used for the more common methods of plant propagation. Once again most of the published material is American.

Cuttings are prepared in the usual way; they are dipped, if desired, into a hormone-rooting powder and then inserted into pots or wooden boxes containing sand and peat moss. The pots or boxes are then completely enveloped with a plastic sheet which is secured in order to prevent any moisture escaping. With the moisture trapped within the 'tent' there is no need for watering, and the cuttings can be left to root undisturbed. The tent may be kept indoors in bright light; or it can be kept out of doors in a partially shaded place during warm weather.

Another method depends upon wrapping each cutting separately in a piece of plastic film. In this case a little sphagnum moss is taken, squeezed to remove excess moisture and placed at the centre of a square of film. The cutting, after treatment with hormone powder, is inserted in the lump of moss. The square of film is then wrapped round to make a bag which is secured with a rubber band. This method has been tried both indoors and out of doors, but under either condition the cuttings need to be kept out of bright sunshine.

The particular advantage of polythene is its transparency, which makes it possible to keep a watch on the progress of root formation on cuttings. One can see when the cuttings have made the desired amount of root growth; the film is then removed, and the cuttings are planted in the usual way.

The same technique can be used to take leaf cuttings of such plants as the African Violet (Saintpaulia).

This method of propagation by cuttings is excellent where space is limited, as the packages can be placed almost anywhere. The cuttings root fairly quickly in most cases. Pelargoniums, for example, have rooted in ten days without needing to be watered a second time.

Instead of giving each cutting a separate plastic bag, it is possible to handle a batch of cuttings all together. In this case one uses a strip of film of, say, 2 ft. long and 5 in. wide. This is laid out flat, and its top half is covered with sphagnum moss. The cuttings are then placed on top of the moss, and then the whole is rolled up into a bundle. One bundle can contain up to twenty cuttings, which root effectively when kept in a frame or propagating house.

AN ARTIFICIAL WATER TABLE

In Britain, Plant Protection have tried using polythene sheeting to make a growing-bed for tomatoes with a constant-level water table. The bed was laid down in a trench dug on a glasshouse border; a layer of sand was put in the trench and the sheeting laid on this. The edges of the sheeting at the surface were protected by a rough wooden frame. A layer of small shingle was put on the bottom of the bed on top of the sheeting and, in order that water would flow easily along the length of the bed, tiled drains cut in half were inverted along the centre of the bed so that they were half buried in the shingle. The bed was then filled up with ordinary border soil containing the same amount of fertiliser as the rest of the house had received. The plants were set out and the bottom of the bed filled with water which rose very satisfactorily through the seven inches of soil above the gravel, so that no ball watering of the plants was at any time necessary.

Mechanically this arrangement proved satisfactory; the plants grew away more rapidly than a set of controls but they fell away severely later, possibly because of lack of nutrients in the small volume of soil enclosed in the constant-level bed.

Seed propagation has been carried out very satisfactorily on plastic film. Somewhat the same method is employed as for cuttings. A handful of moss is wrapped in a plastic square and the seed placed on the moss; the whole is tied with a rubber band leaving a hole at the top for the seeds to get air. The seedlings are removed and planted out as soon as they are large enough to handle.

Plastic bags are being used for the packing of plants for distant delivery. Dormant scions of rose have been packed in them with a little sphagnum moss and have arrived in perfect condition up to five weeks later. At the Arnold Arboretum rose scions were kept in this fashion in a refrigerator for over a year. Using this method of packaging plants can be shipped without soil on their roots, thus avoiding undue weight and carriage costs. The soil is washed off the roots and the plastic bags put on while the roots are still damp. The bags are sealed and then enclosed in a protective packing of wood fibre.

Many people worry about their pot plants when they go away on holiday. Polythene film suggests an answer to these worries. If a piece of this film is wrapped around the entire pot after it has been thoroughly watered it should remain moist for two or three weeks.

FAR AND NEAR

Night Sky in June

The Moon.—New moon occurs on June 1d 04h 03 m, U.T., and full moon on June 16d 12h 06m. The following conjunctions with the moon take place:

June			
2d 16h	Jupiter in conjunction with the moon	Jupiter	1° S.
2d 20h	Mercury ,,	Mercury	1° N.
3d 11h	Venus ,,	Venus	2° N.
12d 11h	Saturn ,,	Saturn	8° N.
17d 08h	Mars ,,	Mars	3° S.

In addition to these conjunctions with the moon, Venus is in conjunction with Pollux on June 12d 04h, Venus 4·9° S.

The Planets.—Mercury, an evening star, sets at 22h and 21h 45m on June 1 and 15, respectively, but after this it draws closer to the sun, and at the end of the month sets almost at the same time as the sun. Venus is an evening star, its times of setting being 22h 30m, 22h 35m and 22h 20m, on June 1, 15 and 30, respectively. Its stellar magnitude varies from $-3·4$ to $-3·5$ and the visible portion of its illuminated disk from 0·852 to 0·767 during the month. Mars rises at 22h 30m, 21h 30m and 20h 15m at the beginning, middle and end of the month, respectively, and is conspicuous until the early morning hours. About the middle of the month it lies a little S. of λ Sagittarii and at the end of the month its westward movement will have brought it N. of γ and δ Sagittarii. On June 24 it is in opposition, when it rises about the time of sunset. Jupiter sets at 21h 40m on June 1 and about 40 minutes after sunset on June 15 and is drawing too close to the sun, with which it is in opposition on June 30, for favourable observation. Saturn sets in the early morning hours—at 2h 40m, 1h 40m and 0h 30m on June 1, 15 and 30, respectively. About the middle of the month it is very close to $\varkappa$ Virginis and its slow westward motion can be detected by comparing its position with this star from week to week. Summer solstice is on June 21d 23h.

A total eclipse of the sun occurs on June 30 and is visible as a partial eclipse at Greenwich from which about three-fourths of the sun's disk will appear to be eclipsed. The path of totality begins in Minneapolis, U.S.A., and after crossing Labrador and the southern point of Greenland, passes over the southern portion of Iceland, the Faroes and Unst in the Shetlands, and then over southern Norway and Sweden. After passing over the U.S.S.R. and the Caspian Sea it ends in northern India. A joint expedition organised by the Royal Astronomical Society and the British Astronomical Association will travel to Lysekil, on the west coast of Sweden, to see the eclipse.

Throughout the British Isles the eclipse will be seen soon after 11h (G.M.T.) as partial and will last for about 2½ hours. The circumstances of the eclipse are as follows:

Eclipse begins June 30d 10h 00·9m G.M.T. Long. 73° 34′, Lat. +29° 47′.

Central eclipse begins June 30d 11h 07·7m G.M.T. Long. 99° 04′, Lat. +42° 22′.

Central eclipse ends June 30d 13h 56·6m G.M.T. Long. −73° 57′, Lat. +26° 19′.

Eclipse ends June 30d 15h 03·4m G.M.T. Long. −50° 46′, Lat. +13° 11′.

Britain's First Heavy Water Pile: Construction starts at Harwell

On May 3 Sir John Cockcroft, director of AERE, Harwell, cut the first sod on the site of a new atomic reactor that is being built at Harwell. This pile, the fourth to be built at the establishment, will be the first in this country to use heavy water as a moderator.

For the last six years Harwell has had available two piles, Bepo and Gleep. They have been used for research in a very wide range of subjects; in particular they have been used for work carried out in connexion with the design of the plutonium-producing piles now in operation at Windscale and the nuclear energy electricity generating station now under construction at Calder Hall. However, the more advanced types of power pile to which Harwell is now giving detailed consideration are likely to operate at a much higher neutron-intensity than has been the case previously, and this should lead eventually to a reduction of capital costs and lower overall costs of reactor operation.

Accordingly, it has been decided to build at Harwell, in addition to the Zero Energy Fast-fission reactor (which has now been operating for some two months), a small research reactor operating at a very high intensity to permit the necessary experimental studies to be carried out. Besides fulfilling this function the new pile will make it possible to produce certain radioactive isotopes such as Cobalt 60 which cannot be made with sufficient specific activity in Bepo. Until now Bepo and the Windscale piles have been the main source of the radioactive isotopes in which AERE has a large international business.

The use of heavy water as a moderator enables the required facilities to be obtained at a lower capital cost than would be possible with a graphite moderated system. The reactor will use as fuel highly enriched uranium which will be supplied from the diffusion plant operated by the Atomic Energy Industrial Group at Capenhurst.

General design of the new pile is being undertaken by the Atomic Energy Research Establishment, whilst detailed design and provision of reactor components will be a responsibility of Head Wrightson Processes Ltd. The Ministry of Works are undertaking civil and general mechanical work in connexion with site services, building and installation.

Atomic Energy Appointments

The Department of Atomic Energy announced in May that Dr. Basil F. J. Schonland, C.B.E., F.R.S., at present head of the Bernard Price Institute of Geophysical Research in the University of the Witwatersrand, is to be appointed Deputy Director of the Atomic Energy Research Establishment at Harwell. The appointment, whereby Dr. Schonland will become Sir John Cockcroft's deputy, will take effect towards the end of 1954.

Dr. Basil F. J. Schonland, who is 58, was educated at St. Andrew's College and Rhodes College, Grahamstown, South Africa, and Gonville and Caius College, Cambridge. From 1915–18 he served with the B.E.F. France, with the rank of Captain R.E. (Signals). He was mentioned in dispatches. Whilst at Cambridge, he did research at the Cavendish Laboratory. From 1941–4 he was a brigadier in the South African Corps of Signals. He was in charge of the Army Operational Research Group (Ministry of Supply), and later served as scientific adviser to the C-in-C 21st Army Group, British Liberation Army. From 1945–50 he was President of the South African Council for Scientific and Industrial Research.

* * *

Two other important appointments have also just been made by the Atomic Energy Department. Mr. K. B. Ross, O.B.E., has been appointed Director of Production in the department's Industrial Group at Risley; Mr. P. T. Fletcher, chief engineer of the Ministry of Works, becomes Deputy Director (Engineering Services) in the same group at Risley. Both appointments take effect on June 1.

Mr. Ross, who is 53 and a chemical engineer by profession, came into the news when the Anglo-Iranian refinery (of which he was general manager) had to be evacuated. A Rhodes scholar (1923–6), he joined Anglo-Iranian as a junior development chemist in 1926. He became general manager of the Abadan refinery in 1951, and he was in charge of the last party to leave it on the evacuation. He afterwards joined the firm of Costain-John Brown to develop a chemical engineering service.

Mr. Paul T. Fletcher, who is 42, has been responsible for several important Government projects. For instance, he was in charge of the organisation of the Government's £2-million Cold Storage Scheme to safeguard the nation's food supplies during the last war. Afterwards he became responsible for developing facilities in the Ministry of Works for handling the engineering requirements for research plant of a heavy character, particularly in conjunction with aeronautical, aircraft engines and similar types of research facilities. He set up a branch known as the Heavy Research Plant Branch which services the wind tunnel and engine test beds of the Ministry of

Supply and a large variety of other equipment for the Ministry of Supply, the Admiralty and the DSIR. He was a member of the mission which went to America after the war to study aeronautical research equipment. He was also responsible for dismantling and removal exercises in connexion with certain German research establishments and arranged for the removal of material to this country. As Chief Mechanical and Electrical Engineer to the Ministry of Works, he has been associated with various aspects of the construction programme for Atomic Energy.

New Fellows of the Royal Society

The following scientists have been elected Fellows of the Royal Society:

Derek Harold Richard Barton, Professor of Organic Chemistry, Birkbeck College, London. Distinguished for his fundamental contributions to the chemistry and stereochemistry of terpenes, triterpenes and steroids.

Thomas MacFarland Cherry, Professor of Mathematics, University of Melbourne. Distinguished for his researches on transonic flow and for earlier work on orbits in celestial mechanics.

Ernest Gordon Cox, Professor of Inorganic and Physical Chemistry, University of Leeds. Distinguished for his contributions to stereochemical problems in inorganic and organic chemistry by the application of X-ray crystallographic methods.

Frederick Charles Frank, Reader in Physics, University of Bristol. Distinguished for his original contributions to the theories of crystal growth, of plastic deformation and of dislocations in crystalline solids.

Austin Bradford Hill, Professor of Medical Statistics, University of London. Distinguished for his work on the application of statistical methods to medical problems, including the evaluation of new therapeutic and prophylactic drugs.

Edwin Sherbon Hills, Professor of Geology and Mineralogy, University of Melbourne. Distinguished for contributions to palaeontology, particularly of Devonian and Tertiary faunas, and for geological studies in Australia.

Sir Christopher Hinton, Managing Director, Industrial Group, Department of Atomic Energy. Distinguished as an engineer who, by his leadership and by direct contributions, has played a major part in the development of large production plants in the Atomic Energy Project.

Frederick Ernest King, Professor of Chemistry, University of Nottingham. Distinguished for his original contributions to synthetical organic chemistry, and for his investigations on wood extractives.

Heinrich Gerhard Kuhn, Lecturer in Physics, University of Oxford. Distinguished for his development of delicate interferometric techniques, his work ranging from the study of continuous spectra to the examination of hyperfine structure.

Hans Werner Lissmann, Assistant Director of Research, Department of Zoology, University of Cambridge. Distinguished for his researches on animal behaviour, including the demonstration of a new form of sensory activity in animals.

Frank Campbell MacIntosh, Professor of Physiology, McGill University, Montreal. Distinguished for his researches in physiology and pharmacology of the central and peripheral nervous system, and for methods of biological assay.

Leonard Harrison Matthews, Director, Zoological Society of London. Distinguished for his work on the physiology of reproduction.

Joseph Lade Pawsey, Assistant-Chief, Radiophysics Division, Commonwealth Scientific and Industrial Research Organisation, Sydney. Distinguished for his contributions to techniques of radio and radar, and in particular for his applications of these techniques to radio astronomy and to the study of the ionosphere.

Max Ferdinand Perutz, Lecturer in Biophysics, University of Cambridge. Distinguished for his elucidation of the structure of complex protein molecules by X-ray diffraction methods; for his detailed study of the structure and properties of haemoglobin; and for his investigations of the structure, deformation and flow of glacier ice.

Alfred John Sutton Pippard, Professor of Civil Engineering, Imperial College of Science and Technology, London. Distinguished for his theoretical and experimental contributions to the theory of structures.

Rosalind Venetia Pitt-Rivers, Biochemist, National Institute for Medical Research, London. Responsible for notable advances in the biochemistry of the thyroid gland.

Reginald Dawson Preston, Professor of Plant Biophysics, University of Leeds. Distinguished for his investigation of the fine structure of plant cell walls.

John William Sutton Pringle, Lecturer in Zoology, University of Cambridge. Distinguished for his researches on neuromuscular co-ordination and the mechanism of equilibration in insects.

Francis John Richards, Senior Principal Scientific Officer, Research Institute in Plant Physiology, Imperial College of Science and Technology, London. Distinguished for his researches on the effects of mineral deficiencies and for his work on developmental morphology in plants.

Claude Rimington, Professor of Chemical Pathology, University College Hospital Medical School, London. Distinguished for his work on the biosynthesis of porphyrins.

Werner Wolfgang Rogosinski, Professor of Pure Mathematics, University of Durham. Distinguished for his contributions to mathematical analysis, particularly in the theory of functions and the theory of series, especially Fourier series.

Frederick Sanger, Biochemist, Medical Research Council, Cambridge. Distinguished for his studies on protein structure, especially that of insulin.

Henry George Thode, Head of Chemistry Department, McMaster University, Hamilton, Ontario. Distinguished for improvements in the technique of mass spectrometry and for the application of mass-spectrometric methods to problems in nuclear physics, chemistry and geochemistry.

William Alexander Waters, Lecturer in Organic Chemistry, University of Oxford. Distinguished for his researches into the mechanism of organic reactions, especially those involving free radicals.

Carrington Bonsor Williams, Head of Department of Entomology, Rothamsted Experimental Station. Distinguished for his pioneer work on migration of Lepidoptera and his studies of insect populations.

New Foreign Members of the Royal Society

At the meeting of the Royal Society, held on April 29, the following were elected Foreign Members of the Society:

Karl von Frisch (Munich); distinguished for his work on the physiology of the chemical and visual sense organs of animals, especially insects and fish.

Otto Loewi (New York); distinguished as being the first to demonstrate the transmission of the effects of nerve impulses by the release of chemical transmitters.

Karl Manne Georg Siegbahn (Stockholm); distinguished for his work on the accurate measurement of X-ray wavelengths, both by crystal and diffraction grating methods.

Otto Struve (Berkeley, California); distinguished for contributions to observational astrophysics, particularly of double stars.

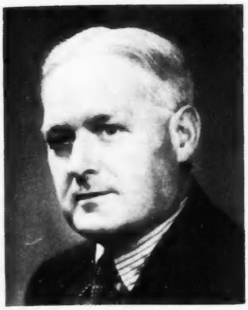
First Synthesis of a Pituitary Hormone

The pituitary gland hormone known as *oxytocin* has been synthesised by a team of chemists led by Dr. Vincent du Vigneaud, Professor of Biochemistry of Cornell University Medical College in New York City. The synthesis is announced in a recent issue of the *Journal of the American Chemical Society*, and is epoch-making, since it is the first synthesis of a pituitary hormone.

Before the composition of oxytocin could be determined, it was necessary to obtain the hormone in a highly purified form; more than ten years of research went into this phase of the work.

Analysis showed that the molecule of oxytocin contained eight different amino acid units, and three molecules of ammonia. About twenty-two amino acids are known to occur in living matter, and those found in the oxytocin molecule are known to chemists as leucine, isoleucine, proline, tyrosine, glutamic acid aspartic acid, glycine and cystine. Further very exacting and intricate chemical work led to the determination of the sequence in which these amino acids are linked together in oxytocin, and also of the disposition of the ammonia molecules, so that in mid-1952 it became possible to write a structural formula of the oxytocin molecule.

New Fellows of the Royal Society



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PROF. W. W. ROGOSINSKI

DR. H. G. THODE

DR. C. B. WILLIAMS

LETTER TO THE EDITOR

STEAM CARS

Sir:

Mr. W. Harold Johnson, in his interesting article on unconventional cars, reminds us nostalgically of the joys of the old steam cars, but I think he is wrong in the reasons he gives for the steam car's disappearance. He would certainly lose his bet in backing the 1954 steam car against its petrol-engined rivals of similar power and price.

The reason for the steam car's failure is fundamental and is just this: the internal combustion engine does its combustion under pressure—say some 5 or 6 atmospheres. To burn the same amount of fuel at atmospheric pressure under a boiler requires a furnace of impractical size. Unless the combustion system of a steam car can be put under quite a high pressure at great risk and considerable complication it is virtually impossible to make a steam car with sufficient sustained power output. A small steam engine is unlikely to have a thermal efficiency of even half that of a corresponding internal combustion engine, so that the steam car might have to burn twice the fuel, which makes the practical possibility even more remote.

Mr. Johnson does not mention the White steamer of which there were perhaps more than any other make. Curiously enough, the White had none of the dash and exhilaration of the legendary steamers, and it was no quieter or smoother than contemporary petrol cars. But it was very reliable. I was part-owner of a Doble about 1926. It was a beautiful machine, but so complicated that it rarely worked. The Doble burner did sometimes light by means of its sparking-plug and, if all went well, the car could be driven away about a minute after switching on. But one never started up in the garage after the first time, because only too often the start was accompanied by a great conflagration.

I am just as great a steam enthusiast as Mr. Johnson and look back longingly to the days when we waited in our Stanley for some splendid Mercedes, Napier or Gobron-Brillé at the bottom of a good hill (getting up a nice boiler pressure the while) and then overtook it at three times its speed in a flurry of white exhaust. I fear, however, that steam can never beat internal combustion in a car. The thermal efficiency is too low and atmospheric combustion is too bulky.

Yours faithfully,

(Sir) OLIVER LYLE.

21 Mincing Lane,
London, E.C.3.

FAR AND NEAR—*continued from p. 254*

The project aimed at the synthesis of oxytocin was still in its preliminary stages when Dr. J. M. Swan, a young Australian chemist, joined the research staff of the Cornell Medical College on leave of absence from C.S.I.R.O. Wool Textile Research Laboratories, Melbourne. Within a few months, largely owing to his efforts, new methods for linking glutamic acid to other amino acids were evolved. Shortly afterwards, by the combined effort of the team, the complete synthesis of oxytocin was accomplished. Final proof of the identity of the compound synthesised was provided by the typical biological effects produced by the synthetic product. It was found to be fully effective in stimulating labour in the human and it likewise possessed milk-releasing activity. Approximately one-millionth of a gram of either the synthetic or natural material given to a patient intravenously, induced milk release in 20 to 30 seconds. Dr. Swan has now returned to the C.S.I.R.O. Wool Textile Research Laboratories in Melbourne, and is continuing research on the synthesis of large peptide molecules.

A New Photo-cell for Infra-red Work

An important contribution to the numerous applications of infra-red radiations in science and industry is made by a new photocell recently introduced by the Communications and Industrial Valve Department of Mullard Ltd. This cell, the 61SV, is of the photoconductive lead sulphide type, and is characterised by extreme sensitivity to infra-red radiations and an unusually high speed of response. It has the additional advantages of a high signal-to-noise ratio, small size and robustness.

These features make the new cell of considerable value for applications in a large number of industries and branches of research. For example, it makes possible notable advances in radiation pyrometry, enabling very small temperature variations to be detected in low temperature sources down to 100° C. This means that the 61SV cell can be used for such typical applications as controlling and monitoring the work in radio-frequency heating and similar industrial set-ups where the detection of temperature or temperature changes without actual contact with the work is required. It is likewise of use for measuring the temperature resulting from severe braking in wheels on railway carriages, and for detecting hot axle bearings, and will also be of considerable value in a number of industrial control and protective systems where the exclusion of visible light necessitates the use of invisible, infra-red radiations. A further and very important extension in this field of application is the monitoring of gas, oil-fired and pulverised fuel furnaces, when the cell is used to follow the temperature fluctuations rather than the luminosity of the flame.

An indication of its sensitivity is provided by the fact that the new cell is capable (under suitable circuit conditions) of detecting the heat radiations from relatively low temperature sources (below 700° C) situated at distances of 100 yards or more away—a feature of great significance in a large number of industrial processes.

Other important applications of the 61SV lead sulphide cell include intruder or burglar alarms, infra-red telephony, and industrial and astronomical spectroscopy. It also opens up possibilities for the rapid measurement of humidity and for gas analysis.

Crossing Pears and Apples

The 44th annual report of the John Innes Horticultural Institution mentions the production of pear-apple hybrids. The fruit which is set by pear-apple pollination tends to drop, and to secure ripe seeds it is necessary to treat the ovary of the flowers with a hormone (β-naphthoxy-acetic acid).

In these experiments the pears used have been Fertility, Conference and Doyenne du Comice; the apples involved are Cox's Orange and 16/36 AT (a tetraploid variety). It seems that owing to a defective root system the seedlings from these 'wide' crossings are not capable of surviving for very long. Healthy plants have, however, been obtained by grafting the pear-apple hybrids, when quite young, on to seedling apples of similar age. They have also been grafted on to seedling pears, but those on apple seem more satisfactory. The report states that the scientists have been successful in obtaining seeds from the tetraploid form of Fertility crossed with the tetraploid apple 16/36 AT. It is possible that the tetraploids will grow more satisfactorily than the diploids and when they reach the fruiting stage will be more fertile. A few seeds have also been obtained from crosses in which the apple was used as the female parent. Seeds were obtained from the $4x$ apple 16/36 AT $\times$ $4x$ Fertility pear and from the diploid's Cox's Orange Pippin apple $\times$ Josephine de Malines pear. Work on these interesting hybrids is continuing.

Two new varieties of tomato have been produced, known respectively as Hertford Cross and Ware Cross. Both hybrids have, in trials under commercial conditions, surpassed Potentate (one of the parents of both these varieties) in earliness, total yield and in quality. Seeds of these two hybrids have been distributed only in small quantities for further trial, but are not yet available for general distribution.

Flower pigments are under investigation by a woman scientist, Mrs. T. O. Dayton, who has discovered that the anthocyanin pigment known as *pelargonidin* is present in the new hybrid Polyantha rose called 'Independence' or 'Cinnabar'. This pigment, which is characteristic of the flowers of *Pelargonium* (the garden 'geranium'), has previously been found in the variety of rose named 'Paul Crampel'.

Mr. W. J. C. Lawrence reports on experiments he made using the soil conditioner CRD-186 in preparing John Innes Composts. He comments: "The results were conclusive. Krilium CRD-186 is no substitute for peat and sand as conditioners in J.I. Composts. Having regard to both this and the previous extensive investigation, I conclude that there is little prospect of soil conditioners of the type tested finding a place in seed and potting composts in Britain. Peat and sand are cheaper and better."

A Society to Study British Mammals

A society which is intended to do for mammals what the British Trust for Ornithology does for birds has just come into being. It is called the Mammal Society of the British Isles. The president is Lord Cranbrook, and the secretary is Mr. T. J. Pickvance, of the Department of Extra-Mural Studies, University of Birmingham, with whom interested readers should communicate.

Study of Underwater Life

A close and intensive study of the marine life around British coasts is now possible by the use of a light self-contained diving apparatus—known as the 'Essjee' aqualung—which is being made by the world-famous diving firm of Siebe, Gorman & Co. Ltd. of Tolworth, Surrey. The equipment enables a swimmer to remain 100 feet underwater for appreciable periods, thus facilitating the prolonged observation of plant and fish life and the close study of rock formations.

With the standard model it is possible to stay underwater at a depth of 60 feet for 15 minutes: at 33 feet the time would increase to 22 minutes. The twin model is basically the same as the standard, but has two compressed air cylinders allowing the swimmer to stay underwater twice as long.

The standard aqualung costs approximately £44, and the twin version approximately £69. A smaller version (the junior 'Tadpole' aqualung) can be used at a maximum depth of 33 feet for 12 minutes, and costs £42.

Books on Civil-Mechanical Engineering

The latest catalogue published by H. K. Lewis & Co. Ltd. of 136 Gower Street, London W.C.1., is a useful bibliography covering the fields of civil and mechanical engineering, and of industrial organisation. Readers will receive a free copy if they apply to this firm of scientific and technical booksellers, mentioning DISCOVERY by name.

Terylene goes into High-pressure Fire Hose

Terylene, the synthetic textile fibre which was entirely developed in Britain although it is now known in many parts of the world by its American trade name of 'Dacron', has just acquired a new use. Terylene fibre is the basis of a new kind of high-pressure hose that is in service with the British Columbia Forestry Commission for fighting forest fires. The specifications for the hose were that it should have a working pressure of 600 lb. per square inch and a burst strength of 1000 lb. per square inch. Terylene was selected as the fibre most able to meet these severe requirements economically. The Terylene hose is made by George Angus & Co. of Newcastle upon Tyne.

Human Senses

By Frank A. Geldard (*London, Chapman & Hall, 1953, 365 pp., 40s.*)

"The basic credo underlying this book is that the highroad to the understanding of human nature is by way of the fundamental role they play in the attainment of knowledge and the regulation of behavior." This sentence occurs in Professor Geldard's preface to his present book.

It is a belief that will rally many supporters. Physicists and chemists and biologists have provided refined tools not available to psychologists of a past era, and in fact have done as much work on the mechanisms of perception as psychologists, some of whom have been so taken with developments calling for no experimental work that they still talk about vision and hearing and so on in terms of results that were not new even half a century ago.

The book is therefore timely. The author is professor of psychology at the University of Virginia (sufficient notice that this is primarily an American book). He has brought together in this book the existing facts and opinions, right up to today, on the mechanisms of sensory perception of every sort. This is much more than the activity of what are usually called the five senses—sight, hearing, taste, smell, touch. Touch, for example, can be resolved into pressure sensitivity and temperature sensitivity, and associated with both is the awareness of pain. In addition there are the internal senses that make us aware of events inside the body and there is the reaction of the aural semicircular canals to movements of internal fluid that comprise our 'sense' of bodily position and balance. The text covers all these and at the end Professor Geldard gives 330 references to books and original papers. His book therefore covers an immense field; not all the field because no book on matters still under investigation can claim finality, but near enough for it to be acclaimed the most up-to-date and comprehensive book so far produced on human sensory mechanisms.

C. L. BOLTZ.

THE BOOKSHELF

Secret Enemy: The Story of a Disease

By James Clough (London, Thames & Hudson, 1954, 259 pp., 18s.)

In this book the author writes from the point of view of a layman. He traces the history of syphilis from ancient times, its first onslaught on Europe in 1495, and its influence on the lives of such famous persons as Beethoven, Nietzsche, Frederick the Great and Napoleon. The early historical part of the book is interesting, but it is inclined to be overdone and becomes somewhat tedious with its constant repetition of the havoc this dreadful disease played on the lives of various sections of different communities in many countries. The author discusses in great detail the early form of treatment and how these proved innocuous since they were based on the principle of the Hippocratean formula of heat succumbing to cold, moisture to dryness, and so on—a principle which indeed ruled the medical world until the 19th century.

When the disease swept over Europe its symptoms were described within a few years and a therapeutic agent of great power, namely mercury, was discovered almost immediately. But the author of this book describes in great detail how medical men were puzzled about the cause of the disease until the first decade of the present century, and the germ had been identified. And it is in the description of Paul Ehrlich and his great work that the reader will find the most exciting part of this story: how he became the father of chemotherapy and announced his great success with '606' in 1910.

There are some excellent character sketches of this great but strange figure who died in 1915 "worn out by the atmosphere of inevitable interruption, traduction, foolish malice and senseless hatred. . . ." The book ends with an account of the present-day precautions and the medical treatment which offers the certain prospect of cure in all but the most advanced stages of infection. This survey of an intricate subject gives a clear idea to the layman what this disease has meant in the past and how medical science has been able to conquer this 'secret enemy'

The Geography of Flowering Plants

By Ronald Good (*London, Longmans, Green, 2nd Edition, 1953, xiv+452 pp., 16 plates, 9 maps, 75 line drawings, 50s.*)

The first edition of *The Geography of the Flowering Plants* was reviewed in DISCOVERY, Vol. 10, Feb. 1949, p. 66. It is a matter for sincere regret that the second, revised, edition gives little opportunity for altering the opinions set out in that previous review. The emphasis appears still to be on uncommon and unfamiliar plants, which must be less suitable for illustrating the principles of plant geography than are common plants of wide occurrence. It is somewhat remarkable that *Galinsoga*, a plant which has spread in recent years over many parts of the earth, is not mentioned in the book. That plant, and some of the other notable spreaders could well repay the attention of the plant geographer, and maybe throw bright light on the theoretical developments of plant geography; it must

be tolerant of a wide range of external conditions, and it must be very well equipped for dispersal.

It may well be asked if it is possible, for one man, in a lifetime of ordinary length, to travel enough, to spend sufficient time in many different places, and with all that to think with the depth demanded of an author who would deal with the plant geography of the whole world. One man can, undoubtedly, spend long hours in the herbarium and in the library, but that may not lead far beyond the accumulation of a vast hoard of second-hand evidence. Before a man is held to be an authority on the British Flora, he is expected, and rightly expected, to make repeated and prolonged visits to the plants growing in their natural surroundings. If such are the requirements imposed on a student of the vegetation of one small country, it would seem that an author who would speak with authority on the geography of the flowering plants of the world, would need to exceed Methuselah in longevity. Moses in energy and maybe Solomon in wisdom.

The Geography of the Flowering Plants is a monument to the industry of the author: but industry can be misapplied.

B. BARNES

Intermediate Botany

By L. J. F. Brimble (*London, Macmillan, 4th edn., 1953; revised in collaboration with Dr. S. Williams and Dr. G. Bond; 505 pp., 20s.*).

This work is designed for Inter students and is suitable for the General Certificate of Education (Advanced Level). It is an excellent example of the value which a publisher can give if he aims at 'maximising' the sale of an individual book and calculating the price accordingly which a few British publishers (e.g. Macmillan's and Bell's) operate so successfully. This volume is quite adequate for its specific purpose, and it is far better illustrated than most books of similar size and similar price.

The text is well written, as one would expect in view of the fact that Mr. Brimble is one of the joint editors of *Nature*. He is also responsible for many of the line drawings, which are not only accurate in their scientific details but also artistically attractive. There is always a temptation when revising a book of this type to include so many new facts that the main principles become overlaid by detail. Mr. Brimble shows his editorial qualities by keeping this tendency well under control; thus, while such things as penicillin, streptomycin and aureomycin are mentioned he has not distorted the general line of the relevant section of this elementary text, which concentrates on the *elements* of the subject.

Plant Anatomy

By K. Esau (*New York, John Wiley; London, Chapman & Hall, 1953; 735 pp., 72s.*)

Professor Esau has done a valuable service to teachers and students by condensing into one well-illustrated volume the results of a vast number of scattered research papers. Although there are inevitably some omissions, her book has no equal as a guide to the anatomical literature of the last few decades.

As a general textbook, however, it is much less satisfactory, and has suffered from its author's excessive preoccupation with the latest work. Sometimes the effect is merely ludicrous, as when a 1937 paper is cited as authority for the remark that some monocotyledonous stems undergo secondary thickening! Sometimes there are inconsistencies inexusable in a work with such a comprehensive title; thus *velamen* is mentioned (with a reference to a paper published in 1940), but *diaphragms* and *aerenchyma* are entirely omitted, apparently because on these topics there were no modern researches to quote. On the same principle the whole subject of anomalous secondary thickening is allotted much less space than are a few modern observations on collenchyma cell walls.

There are few attempts to evaluate the work quoted. Impartiality would appear to be carried altogether too far when such dubious speculations as phytonism and carpel polymorphism are cited without any indication of the low esteem in which they are now generally held.

Some morphological topics are accorded a treatment too brief to be of real value. The section on phyllotaxy, for example, is well calculated to irritate a reader who understands the subject, without it materially assisting anyone who does not.

At times the literature is quoted with a startling lack of understanding. The discussion of the number of xylem poles in roots altogether fails to make the point that the number is taxonomically controlled in radicles but not in lateral roots. In dealing with cell shape, the tetrakaidecahedron is introduced without any clear statement of its theoretical significance, and the minimal figure (as distinct from the orthic form) is not mentioned at all. The departure of cells, bubbles, and compressed shot from the expected form is discussed, but the vital point that in all these things pentagonal faces predominate is completely missed.

There are a few errors of fact, as in the statement that *Trifolium* has no interfascicular xylem, but in the main the book is a laborious, methodical and accurate compilation which will be immensely useful. It is a pity that it should be so indiscriminate and so uncritical.

K. J. DORMER

The High-Speed Internal-Combustion Engine

By Sir Harry R. Ricardo, LL.D., F.R.S. (*Blackie & Son, Ltd., 1953, 420 pp., 40s.*)

This author's work and reputation require no boosting in any book, and no eulogy by any reviewer. For some thirty years nowhe has pioneered, not to say dominated, internal combustion-engine development and design. Nevertheless (or perhaps because of all this), I find this new edition of his standard literary work somewhat disappointing.

This fourth edition of the book unlike the third which was written by H. S. Glyde, B.SC.) is the author's own work, with of course the assistance of his staff of whom Mr. Glyde was one until his death in 1947. We are now presented with a résumé of the author's ideas and theories on internal-combustion piston engines—turbines and the like are deliberately omitted from the book. In a broad sense we have here a comprehensive survey of modern theoretical knowledge of undoubted value for those who already know the subject but too broad to give much factual information to those who need it. That function was better served perhaps by earlier editions to which this book bears little resemblance apart from the title, being concerned mainly with theory and efficiency. There is little about some practical problems of which solutions would certainly help internal-combustion progress and those whose job it is to work or play with such engines.

There is, for example, much about the behaviour of the charge inside the cylinder, but little on how to get it there—i.e. about distribution problems and the pros and cons of one or more carburettors for spark ignition engines, or the best method of valve operation or design of valve gear; these are barely touched upon, perhaps because both topics were covered in a chapter in the third edition of 1941. Nevertheless, one suspects that there may have been some progress during the last twelve years worthy of record.

There is much about the single sleeve valve (Burt McCollum). As he points out this single sleeve has attained great success in aero engines, but although he mentions he does not explain its lack of success in road vehicles and in small marine engines.

There is much in this book about the improvement of fuels, but strangely enough there is nothing about metallurgical advances.

It is not only fair but necessary to say that a full survey of internal-combustion progress or present production conditions would require far more than the 420 pages of this volume, and the author can doubtless justify his emphasis on theoretical aspects rather than on more practical considerations which would have given the book a wider appeal. But sometimes he seems to assume a knowledge that some of his readers may lack and this is particularly evident in some of the diagrams, as for instance in the one illustrating the relationing between mixture strength and rate of burning. From the caption one assumes that the upward curve on the diagram indicates a rising rate of burning but the time scale on the side shows that the upward curve actually shows a decrease in burning rate; if more than the existing couple of lines had been devoted to explanation in the text some misapprehensions that many readers could form might have been cleared.

However, the author's standing is such as to justify his own choice as to his treatment, and for those who have sufficient background knowledge this fourth edition may well maintain the reputation of its predecessors.

W. H. J.

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